Technical Report

Sustainable intensification of cereal-based farming systems in the Guinea-Sudano-Savanna of West Africa

01 October 2013 to 31 March 2014

Submitted to:

United States Agency for International Development (USAID)

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Published by: International Institute of Tropical Agriculture (IITA)

May 2014
www.africa-rising.net

The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads an associated project on monitoring, evaluation and impact assessment.

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Contents

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AMEDD	Association Malienne d'Eveil et de Developpement Durable, Mali
ARI	Animal Research Institute, Ghana
AVRDC	The World Vegetable Center
CBOs	Community-based Organizations, Ghana
CIAT	International Center for Tropical Agriculture
CMDT	Compagnie Malienne de Developpement des Textiles, Mali
CRI	Crops Research Institute, Ghana
FRI	Food Research Institute, Ghana
GLDB	Grains and Legumes Development Board, Ghana
GUIFFA	Guinea Fowl Farmers Association, Ghana
HI	Heifer International
ICRAF	World Agroforestry Center
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IFPRI	International Food Policy Research Institute
IER	Institut d'Economie Rurale, Mali
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INSTI	Institute for Scientific and Technological Information, Ghana
IWMI	International Water Management Institute
KNUST	Kwame Nkrumah University of Science and Technology, Ghana
MOBIOM	Mouvement Biologique du Mali, Mali
MoFA	Ministry of Food and Agriculture, Ghana
MoH	Ministry of Health, Ghana
NORGFA	Northern Region Guinea Fowl Farmers Association, Ghana
SARI	Savanna Agricultural Research Institute, Ghana
SEEDPAG	Seed Producers Association of Ghana
SRI	Soil Research Institute, Ghana
UDS	University for Development Studies, Ghana
UG	University of Ghana, Ghana
WIENCO	Wienco Seed Company, Ghana
WU	Wageningen University, The Netherlands
WIAD	Women in Agriculture Development, Ghana
WRI	Water Resources Institute, Ghana

Summary

Implemented work and achievements for the period October 2013 to March 2014 for the Africa RISING project in Ghana and Mali are reported. Surveys to collect baseline data for farming systems analysis, household nutrition, nutritional status of children, pig and poultry production and pearl millet cropping systems were completed. Data were analyzed and reported. Farmer-participatory livestock and crop trials initiated during the first or second year of the project ended during the period. Data were analyzed and reports written. The field trials identified improved housing for backyard poultry and agronomic management practices and cereal (maize and sorghum, and millet), legume (soybean and cowpea) and vegetable varieties for intensive crop production. Modeling and Geographic Information Systems and remote sensing technologies will be used to extrapolate results from the field/plot level activities to wider recommendation domains and larger scales using modeling and GIS and remote sensing techniques. Quality seeds of cereals, legumes and vegetables were produced for multiplication and dissemination to farmers and future project activities. Group and individual training were conducted to strengthen the capacity of farmers and researchers and development partners. Project outputs were disseminated through farmers' field days and farmer field schools, exchange visits and video shows. Meetings of stakeholders, Project Steering Committee and Program Coordination Team meetings were organized during the period.

1 Introduction

1.1 Africa RISING Program

As part of the Feed the Future Initiative, the United States Agency for International Development (USAID) is supporting an innovative multi-stakeholder agricultural research program, the Africa Research in Sustainable Intensification for the Next Generation (Africa RISING). The program's main objective is to identify and validate scalable options for sustainable intensification of key African farming systems to increase food production and improve livelihoods of smallholder farmers and at the same time conserve or improve the natural resource base.

Africa RISING is a three-in-one, five-year research program launched in 2011. It brings together a wide range of research and development partners from the CGIAR and the national agricultural research and extension systems (NARES), farmers, input and output dealers and policymakers to develop management practices and technology combinations that use the farming systems research and extension approaches to better integrate crops (cereals, legumes and vegetables), livestock (including poultry), and trees and shrubs in mixed-farming systems with the aim of improving whole-farm productivity, nutrition and incomes of small-farm families without degrading the environment. It will also develop innovations that effectively link farmers to markets and input suppliers.

The three projects are:

- Sustainable intensification of crop-livestock mixed farming systems in the Guinea-Sudan-Savanna Zone of West Africa – led by the International Institute of Tropical Agriculture (IITA);
- Sustainable intensification of crop-livestock integrated farming systems in the Ethiopian highlands – led by the International Livestock Research Institute (ILRI); and
- Sustainable intensification of cereal-legume-livestock integrated farming systems in East and Southern Africa – led by IITA.

The International Food Policy Research Institute (IFPRI) is responsible for monitoring, evaluation, and impact assessment across all three projects.

The program is organized around four research outputs that are logically linked in time and space, namely:
1. Situation Analysis and Program-wide Synthesis
2. Integrated Systems Improvement
3. Scaling and Delivery of Integrated Innovation
4. Integrated Monitoring and Evaluation

The first research output covers the activities that are necessary to ensure that project activities are able to characterize and stratify target communities effectively so that promising interventions are identified and inappropriate interventions rejected. The second is delivered via a broad approach of participatory technology development and/or identification. This requires projects to allow for the identification of existing sound practices within communities that might be more widely propagated, the adaptation of these and other exogenous innovations, and the more effective combination of innovations from multiple sources.

The first two outputs will generate integrated technology combinations that are more effectively targeted on farmers' real development needs. This third output recognizes that, even where such technology combinations can be identified, the approaches used for scaling them out may not always be effective and seeks to redress this shortcoming. The fourth output, which relates to monitoring adoption and farmer preferences and assessing economic and environmental impact of the project activities, is the responsibility of IFPRI.

1.2 Africa RISING in West Africa

Africa RISING is being implemented in 25 intervention communities in the three northern regions of Ghana (Fig. 1), and 10 villages in the Bougouni-Yanfolila and Koutiala districts of the Sikasso Region in southern Mali (Fig. 2). It is intended to result in spillover effects to other similar agro-ecological zones.
The farming systems in the region are dominated by small-scale, resource-poor farmers whose livelihoods depend on rain-fed crop, livestock and crop-livestock farming systems. Main staple crops are cereals (maize, rice, sorghum, pearl millet), legumes (groundnut, cowpea, soybean, Bambara nut, pigeon pea), and vegetables (roselle, okra, pepper, onion, eggplant, tomato, amaranths, pumpkin). The cereals are either grown in pure stands or intercropped/rotated with the legumes and a variety of vegetables.
Crop yields on farmers' fields are generally poor due to low and variable rainfall; drought; low and declining soil fertility; use of low yielding varieties; lack of quality seed of improved crop varieties and land preparation equipment; high cost of inputs and postharvest losses; labour constraints that lead to poor growing conditions (late sowing, sub-optimal plant populations, inadequate control of weeds, *Striga*, pests and diseases); and low use of organic or mineral fertilizers.

Cattle, sheep, goats, pigs, chicken, guinea fowl, turkeys and ducks are reared for meat, milk, land preparation, transport, manure and cash. The animals are mostly managed under extensive and semi-intensive systems with limited feed, shelter, health care and breeding management. Productivity of the animals is low due to inappropriate husbandry (feeding, health care, housing and breeding) practices that result in high mortality rates. Farmers have limited access to veterinary services and improved livestock breeds. In general, the crop and livestock enterprises are weakly integrated.

Diets of most rural poor farm families are often dominated by the intake of basic staple foods (e.g. maize, rice, millet and sorghum) which are usually deficient in micronutrients such as vitamin A, iron and zinc needed to prevent malnutrition. The nutritional status of most farm households, especially pregnant women, breastfeeding mothers and children below 24 months of age, is therefore poor,

leading to chronic malnutrition linked to low income, unsuitable food processing and feeding practices and iron deficiency.

Farmers have limited access to input and output markets. Enabling institutions and policies are also lacking. Due to inadequacies of traditional promotional and scaling-up/out pathways, there is a large unmet demand for information and technology, especially by women. This has led to low adoption of improved technologies and best practices by farmers to reduce food insecurity, poverty and natural resource degradation.

1.2.1 Implementation strategy

Participatory approaches are used to identify and implement activities to address the bio-physical and socio-economic constraints of the farming systems in the intervention communities in each region by multi-disciplinary research teams from ARI, AVRDC, FRI, IITA, ILRI, KNUST, MoFA, MoH, SARI and UDS. Similarly in Mali, activities are implemented by multi-disciplinary and multi-institutional partners such as AMASSA, AMEDD, AVRDC, CMDT, ICRAF, ICRISAT and MOBIOM. The activities are implemented on-farm and on-station. The on-farm activities consist of activities managed by researchers; researchers and farmers; and farmers only. In addition to comparing intensified practices with farmers' practices, the on-farm activities are used to demonstrate new technologies and/or a combination of technologies through farmers' field days, farmers' field schools and exchange visits. They are also used to train farmers, extension and research assistants. The on-station activities are mostly used by graduate students as part of their dissertation research to test and/or develop new technologies.

Most of the activities are implemented at the plot or field levels. Nevertheless, results and outputs from the activities can be extrapolated to larger scales and bigger recommendation domains using modeling, Geographical Information Systems (GIS) and Remote Sensing techniques. For example, our preliminary GIS analysis showed that results from plot activities implemented at the Natodori intervention community in the Upper West region can be applied to other West African countries with similar agro-ecology and socio-economic environment – Nigeria (9%), Guinea (49%) and Cote d'Ivoire (34%).

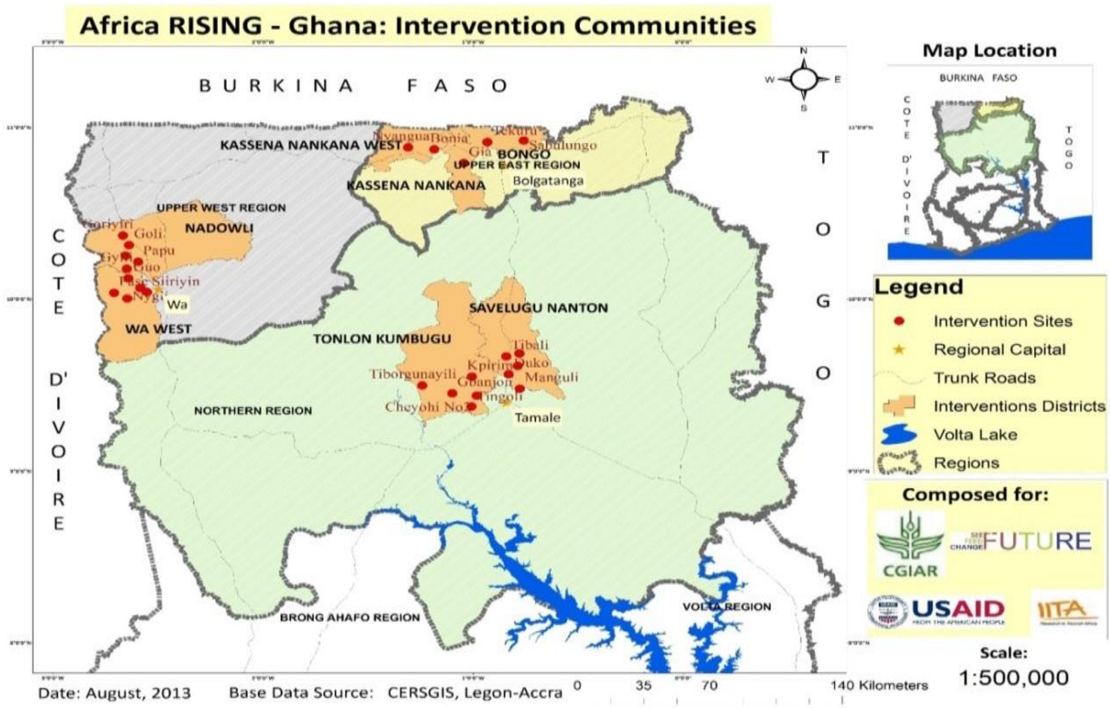


Figure 1. Africa RISING intervention communities in Ghana.

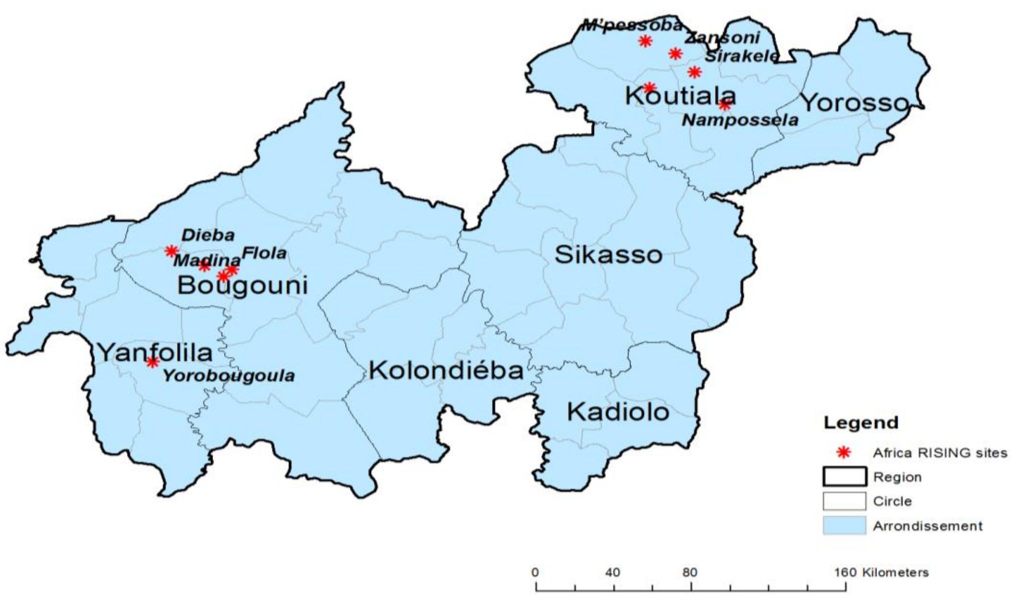


Figure 2. Africa RISING intervention villages in Mali.

2 Achievements

2.1 Situation Analysis (Research Output 1)

The baseline surveys in Mali and Ghana to be conducted by IFPRI are yet to be implemented. Therefore, the interdisciplinary research teams initiated own surveys to collect baseline data necessary for their research.

2.1.1 Community mobilization in Ghana

Community mobilization and sensitization continued during the reporting period. The list of farmers or households interested in the project activities was revised in each community. A total of 1,783 farmers were interested, 41% of whom were female (Table 1).

Table 1. Prospective farmers in Africa RISING intervention communities, Ghana, March 2013

Region	Communities	Female	Male	Total
Northern	10	220	396	616
Upper East	5	219	328	547
Upper West	10	295	325	620
Grand Total	25	734	1049	1783

2.1.2 Farming systems analysis

The first phase of a farming systems analysis in Ghana (Northern, Upper West and Upper East regions) and Mali (Bougouni and Koutiala areas) was completed by the Department of Plant Sciences of Wageningen University and Research Centre (The Netherlands) during the period. The objective of this first phase was to characterize farming systems in project intervention areas, to make farm typologies, and to find constraints and entry points for sustainable intensification and innovation at the farm level.
It comprised four steps:

1. Rapid characterization of farming systems by a survey.
2. Detailed diagnosis of a representative subset of farms through a detailed survey.
3. Model-based exploration of trade-offs and synergies within the farms, which results in set of alternative farm configurations that perform different in productive, economic and environmental performance indicators.
4. Selection of a desirable farm configuration, as identified by the farmer and other relevant stakeholders on the basis of the performance indicators, for fine-tuning and redesigning the case study farm.

The steps 2, 3 and 4 can yield suggestions and entry points for farming systems adjustments. Steps 3 and 4 were performed for the Ghana case study. The detailed results have been reported (Timler et al., 2014) *(https://dl.dropboxusercontent.com/u/17758665/AR/Report/2014_03_Report_WUR.doc).*

The results showed a large variation in farm size and endowment in both countries. This observation stresses the need to consider farm typologies in targeting of technologies. Farms were grouped into farm types on the basis of structural and functional farm characteristics that reflect their size (surface area and livestock density), production orientation (subsistence or market) and income sources (on and/or off farm).

In most regions the farmers cultivated 2-4 crops. Cereals (maize, sorghum and millet) and legumes (groundnut, cowpea and soybean) were the most important crops in Koutiala district in Mali, while cotton, sorghum and millet also occupied large areas. The crop yields reported by the farmers were extremely variable and often very low.

Livestock numbers per farm differed greatly between the intervention communities within each country. Key livestock species kept were cattle, sheep, goats, domestic chickens and guinea fowl. Generally, livestock management was sub-optimal.

The stated labor inputs per unit of area were variable but tended to decline with farm size. The percentage of female-headed households differed strongly between regions and was as low as 1-2% in the Northern region of Ghana, while in the Upper West and Upper East regions in Ghana on average 40-50% of the households were female-headed.

The main constraints and critical points to sustainable intensification and innovation were identified as:

- Household level farm productivity and on-farm income generation and returns to labor are low; in various cases food availability is insufficient during parts of the year.
- Women's representation in decision-making and ownership is often limited, although large differences between regions exist. Women indicated that the limited availability of food, clean water, options for sanitation and possibilities for education are important constraining factors. Moreover, limitations in opportunities for post-harvest storage and processing of farm products were reported.
- Limited or untimely availability of resources like seeds and fertilizers. Lack of improved crop varieties and animal breeds that are more productive or better adapted (e.g. early maturing and drought-tolerant).
- Crop yields were low. Combined with the small farm areas and seasonality this resulted in food shortages in parts of the year. On the other hand, for cash crops the low productivity led to small volumes of produce for sales and income generation. Moreover, post-harvest storage losses are large in some cases.
- Problems with pest and weed control, in particular *Striga,* is an important issue.
- The management, storage and conservation of crop residues and animal manures were generally poor. As a consequence, the losses of organic matter and nutrients were probably large and availability of these organic resources for soil improvement was limited, which was reflected in low soil organic matter contents and soil fertility.
- The feeding of livestock was sub-optimal. Larger animals graze crop stubbles and rely on open and common areas for grazing. The management of grazing areas is often inadequate and availability of watering points can be limiting. Diseases are reported to affect animal performance negatively. As a result, the productivity levels of all types of animals kept on the farms (mainly cattle, goats, sheep, chickens and doves) was low.
- The access to training and advice on land preparation, crop cultivation, animal husbandry and farm management is often limited. In particular women indicated that possibilities for education were lacking.
- Farmers often reported being challenged by climatic conditions. These issues ranged from overall unfavorable conditions for agriculture, to variability and unpredictability, and trends of changes in climate.

The following entry points for sustainable intensification and innovation at farm level were identified and analyzed:

- Encourage seed saving and selection, possibly as a joint effort within the community, focusing on collecting the best seeds. This could serve as a backup if no seeds are available in the market before planting, or when prices are high, through the establishment of community seed banks.
- Improved water management, for instance through water harvesting to enhance the availability of clean water for human consumption and irrigation of (vegetable) crops.
- Diversifying cropping, for instance by growing more vegetables, where collected water (see above) could be used. Increase the productivity and integration of legumes in rotations and by intercropping and double-up legume cultivation, which contributes to nitrogen availability. This could contribute to improved nutrition and possibly health, or generate an alternative income source and spread risks of crop failure and price volatility.
- Fencing of fields to allow better livestock and crop residue management. This can be implemented with artificial or natural fences.
- Developing new strategies for pest and weed management and *Striga* control.
- Improved management of collected organic resources like manure and crop residues. Manure can be stored anaerobically by covering with an impermeable sheet to reduce organic matter degradation, to avoid wash-out of nutrients in case of heavy rains and to avoid exposure to air so that ammonia volatilization is prevented. Crop residues could be harvested in a less mature stage of development and stored (conserved) in an appropriate way to preserve their feeding quality.
- The role of livestock on farms could be strengthened. This could contribute to nutrient cycling and the production of high-quality and high-value products.
- There is a strong need for education and training, and for the development of institutional arrangements and community-based organizations. These could support the development and implementation of many of the entry points mentioned above.

2.1.3 Baseline surveys

2.1.3.1 Household nutrition

A team of researchers from FRI, MoH and UDS led a survey on household nutrition. Five hundred and twenty two households from six intervention communities in the Northern (Cheyoli and Tibali), Upper West (Guo and Zuko) and Upper East (Bonia and Sabulungu) regions were interviewed. Data was collected on food consumption pattern, food frequency, dietary diversity, existing foods/food groups and their seasonal availability between October and November 2013. Green leaves of local vegetables were sampled from markets and farms in the Wa municipality and analyzed for micro-mineral (iron, copper, manganese and zinc) concentrations.

Figure 3 shows food groups consumed by the households in the three regions. Consumption of milk, eggs and meat and meat products were very low. One reason for this is that households preferred to sell their livestock and livestock products for cash to meet family needs, e.g. to pay health and education bills. Similarly, fruit consumption was below 20% in all the regions. Legume consumption was highest in Upper East region and was around 60%, but the frequency of consumption is important to ensure adequacy.

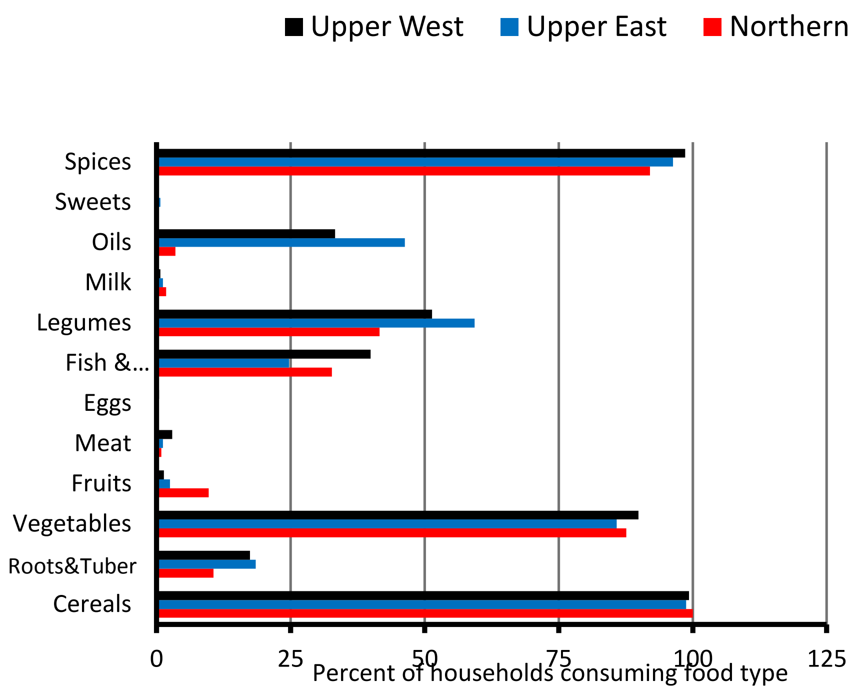


Figure 3. Food groups and percent of households consuming food group

The micro-mineral concentrations in leaves of the traditional leafy vegetables varied among species (Table 2). The micro-mineral concentrations in some species were above the minimum requirements for humans, suggesting that promoting the consumption of the local leafy vegetables could improve dietary micro-mineral status in the communities. Research is warranted on integrated soil fertility management strategies to increase micro-mineral concentrations in the traditional leafy vegetables.

The food frequency results showed that 91.2% (Northern Region), 94% (Upper East Region) and 91% (Upper West Region) consumed soybeans less than 3 times a week, while more than 60% (64.4%-88.9%) of households also consumed cowpea less than 3 times a week. The mean dietary diversity score of 4.6 out of 12 food groups differed significantly across the three regions. A higher score will indicate adequate food diversification, and hence a higher tendency to meet nutrient requirements. The results suggest the need for nutritional interventions to promote the consumption of protein source foods, green leafy vegetables and fruits.

Table 2. Micro-mineral concentration (mg/kg) in fresh leaves of local leafy vegetables in Wa, Ghana, 2013

Species	Copper[1]	Iron	Manganese	Zinc
Amaranths	1.93 ± 0.16^{de}	54.02 ± 6.34^{m}	5.71 ± 0.39^{st}	5.87 ± 0.88^{jz}
Sorrel	2.29 ± 0.01^{fg}	23.47 ± 2.54^{i}	5.32 ± 0.21^{st}	0.69 ± 0.09^{x}
Bean	1.81 ± 0.09^{cde}	50.61 ± 0.93^{m}	12.03 ± 0.62^{v}	4.48 ± 0.28^{jyz}
Bitter	1.59 ± 0.04^{abc}	34.94 ± 0.13^{k}	13.33 ± 0.97^{v}	9.58 ± 0.57^{b}
Cassava	2.01 ± 0.26^{ef}	34.71 ± 6.64^{k}	20.31 ± 1.01^{w}	2.40 ± 0.25^{c}
Tossa	1.46 ± 0.17^{ab}	71.83 ± 4.33^{p}	5.61 ± 0.06^{st}	4.26 ± 0.89^{yz}
Pumpkin	1.64 ± 0.78^{bcd}	70.63 ± 1.51^{p}	9.00 ± 0.09^{u}	9.38 ± 1.31^{b}

[1]Means in a column followed by different letter(s) differ (P<0.05)

At present, most families take legumes in the form of *dawadawa* which is a condiment, and in isolated cases as *gable*, *tubani* and *khebab*. The farm-families were willing to take the needed protein from legumes, particularly soybeans, if they are taught to utilize it and are given the necessary processing equipment. This observation stresses the need for a value-chain approach for implementing project activities.

2.1.3.2 Nutritional status of children

Anthropometric data was collected on children up to 5 years in each household surveyed. The children were weighed and their heights were taken for the determination of their nutritional status. The World Health Organization (WHO) Anthro software was used to convert weight, height and age of child (months) into weight for age z score (WAZ), weight for height z score (WHZ) and height for age z score (HAZ). As per the agreed global standards, the following categories were used for the z-scores: Normal (Well nourished) = -1 to 0; Marginally under-weight/wasted/stunted or mildly malnourished = -2 to -1; Moderately under-weight/ wasted/stunted (Moderately Malnourished) = -3 to -2; Severely under-weight/wasted/stunted (Severely Malnourished) = < -3.

About 64% of children of 0-60 months were normal/well-nourished in the three regions (Table 3). More than 30% were marginally malnourished, whilst about 5% were moderately malnourished. The extent of malnutrition varied among the intervention communities (Fig. 4). It was relatively higher in the communities in the Northern Region than those in the Upper West and Upper East Regions. The results suggest that rigorous nutrition communication and promotion should accompany interventions aimed at improving household food security and incomes.

Table 3. Nutritional status of children aged 0-60 months in six Africa RISING intervention communities, Ghana, 2013

Region	Moderately malnourished N (%)	Marginally malnourished N (%)	Normal/Well-Nourished N (%)
Northern (n=198)	21 (10.6)	80 (40.4)	97 (49.0)
Upper West (n=148)	2 (1.4)	31 (20.9)	115 (77.7)
Upper East (n=146)	2 (1.4)	40 (27.4)	104 (71.2)
Total (n=492)	25 (5.1)	151 (30.7)	316 (64.2)

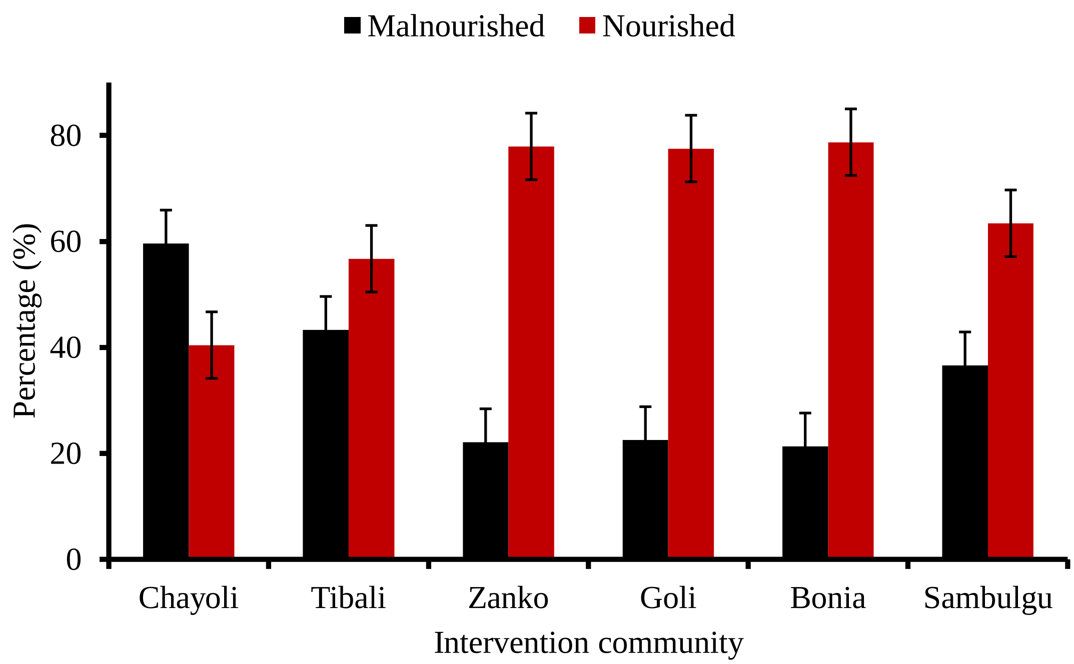


Figure 4.
Nutritional status of children aged 0-60 months at intervention communities in the Northern (Chayoli, Tibali), Upper West (Zanko, Goli) and Upper East (Bonia, Sambulgu) Regions, Ghana, 2013

Table 4 presents the levels of wasting, stunting and underweight among the children in the three regions. Averaged across regions, 72%, 43% and 45% of children aged 0-60 months were not wasted, stunted and underweight, respectively.

Table 4. Classification of children at the Africa RISING intervention communities in the Northern (NR), Upper West (UWR) and Upper East (UER) Regions, Ghana, using weight by height (WHZ, wasted), height by age (HAZ, stunted) and weight by age (WAZ, under-weight) z-scores, 2013

		Classification			
		Severely	Moderately	Marginally	Normal
	Region	N (%)	N (%)	N (%)	N (%)
Wasted (WHZ)	NR (n=202)	12 (5.9)	15 (7.4)	46 (22.8)	129 (63.9)
	UWR (n=150)	0 (0.0)	7 (4.7)	20 (13.3)	123 (82.0)
	UER (n=147)	1 (0.7)	6 (4.1)	31 (21.1)	109 (74.1)
	Total (n=499)	13 (2.6)	28 (5.6)	97 (19.4)	361 (72.3)
Stunted (HAZ)	NR (n=201)	19 (9.5)	63 (31.3)	56 (27.9)	63 (31.3)
	UWR (n=149)	3 (2.0)	19 (12.8)	46 (30.9)	81 (54.4)
	UER (n=146)	5 (3.4)	23 (15.8)	48 (32.9)	70 (47.9)
	Total (N=496)	27 (5.4)	105 (21.2)	150 (30.2)	214 (43.1)
Underweight (WAZ)	NR (n=199)	18 (9.0)	35 (17.6)	77 (38.7)	69 (34.7)
	UWR (n=148)	1 (0.7)	14 (9.5)	45 (30.4)	88 (59.5)
	UER (n=146)	1 (0.7)	18 (12.3)	61 (41.8)	66 (45.2)
	Total (N=493)	20 (4.1)	67 (13.6)	183 (37.1)	223 (45.2)

2.1.3.3 Ruminant feed resources

The International Livestock Research Institute (ILRI) led a team of researchers from ARI, UDS, MOFA and KNUST in Ghana, and from ICRISAT, IER and AMEED in Mali to document existing and potential feed resources, current use and cost, and assessed gaps with respect to demands for ruminant (cattle, sheep and goats) production using the Feed Assessment Tool (FEAST).

Table 5 presents constraints and opportunities for ruminant production in Ghana. Grazing and crop residues were identified as the key feed resources (Fig. 5).

A similar study in six villages at Koutiala and Bougouni/Yanfolila in Mali showed that the key constraints to ruminant production were feed shortage, disease, restricted livestock mobility which hinders access to natural pasture, and housing. Therefore, livestock-related interventions should be multi-faceted including feed, animal health and housing. Grazing natural pasture accounted for 40-55% of the diet of ruminants (Fig. 6). Crop residues accounted for 20-35%, and naturally occurring and collected fodder accounted for 10-15% of the ruminants' diet.

Table 5. Sheep and goat production constraints and suggested solutions, Ghana

Main problems	Suggested solutions
1. Poor housing	Support in cash for housing construction or housing package
2. High disease and mortality	Confinement of animals to reduce exposure and better access to veterinary services
3. Lack of improved breeds	Better management of the local breeds, buying the improved breeds and the supply of these breeds in the form of support
4. Conflict with crops farmers	Confinement and herding of the flock
5. Inadequate feed	Collection and conservation of crops residue; subsidized concentrate feeds and training in better feeding practices
6 Low prices offered by marketing agents and processors for animals	Formation of farmer groups to negotiate good prices for members; and weighing of animals and sale according to animals' weight
8. Lack water in the dry season	Construction of dug-outs and small reservoirs and supply of materials for rain water harvesting
9. Access to credit	Formation of farmers groups and cooperative to facilitate access to credit and external support
10. High cost of veterinary drugs	Government subsidy and support from NGOs in form animal health service package

Common crop residues in the study sites included cereal (maize, sorghum, millet, rice) straw and bran, legume (groundnut and cowpea) hay, and cotton residues/byproducts (cotton grain residue, cotton seed cake). Availability and quality of these crop residues varied with season. The large part of the crop residues are normally fed to the household animals and/or sold, particularly groundnut haulm, while a small proportion is left on the field and burnt to improve soil fertility, according to the respondents.

Based on area of land cultivated, the majority of the farmers were in small to medium categories (Table 6). Nearly all the households interviewed owned at least one draught animal or oxen which could be attributed to the need for animal power for cotton production (Table 7). In view of the importance of draught animal to the crop-livestock systems in Koutiala and Bougouni/Yanfolila, livestock interventions should address feeding strategies to improve the body condition of oxen in the late dry season/early wet season for field preparation. All households interviewed owned 5-25 small ruminants (sheep and

goats) per household. The small ruminants are ready source of cash to meet emergency household need. Therefore, interventions to improve small ruminant production will be popular in the study sites.

Table 6. Classification of farmers based on land ownership in Africa RISING districts, Mali, 2013 (farmers' estimates)

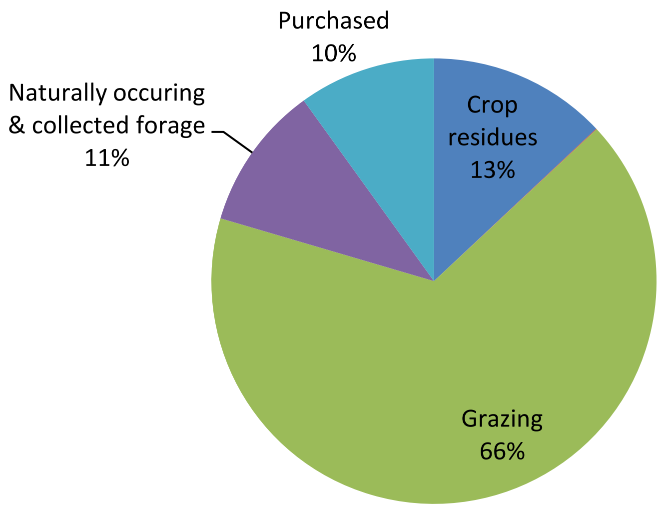
	Bougouni-Yanfolila		Koutiala	
Category of farmers	Land size (ha)	% households	Land size (ha)	% households
Landless	0	0	0	0
Small	<8	44.44	<12	41.67
Medium	8-13	30.56	12-27	36.11
Large	>13	25	>27	22.22

Table 7. Livestock ownership in Africa RISING communities, Mali, 2013

Animal species	Category	Bougouni-Yanfolila	Koutiala
Cattle	Lactating cow	2.59±0.69[a]	1.26±0.33[b]
	Non lactating cow	3.91±1.21[a]	2.78±1.38[a]
	Bulls	0.89±0.27[a]	1.17±0.60[b]
	Draught oxen	1.81±0.31[a]	2.35±0.29[a]
	Calves	1.26±0.68[a]	1.08±0.33[b]
Sheep	Sheep	0.27±0.06[a]	0.72±0.16[b]
Goat	Goat	0.67±0.15[a]	0.84±0.13[a]
Donkey	Donkey	0.50±0.08[a]	1.36±0.16[b]
Poultry	Poultry	0.13±0.02[a]	0.22±0.03[b]
Pig	Pig	0.01±0.01[a]	0.21±0.13[b]

[a]Means in a column followed by different letter differ (P<0.05).

a) Bonia, Upper East Region



b) Tibali, Northern Region

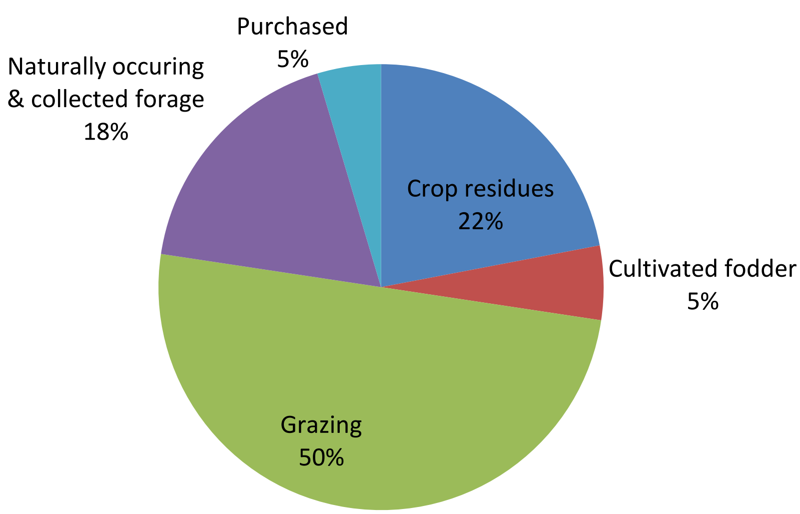
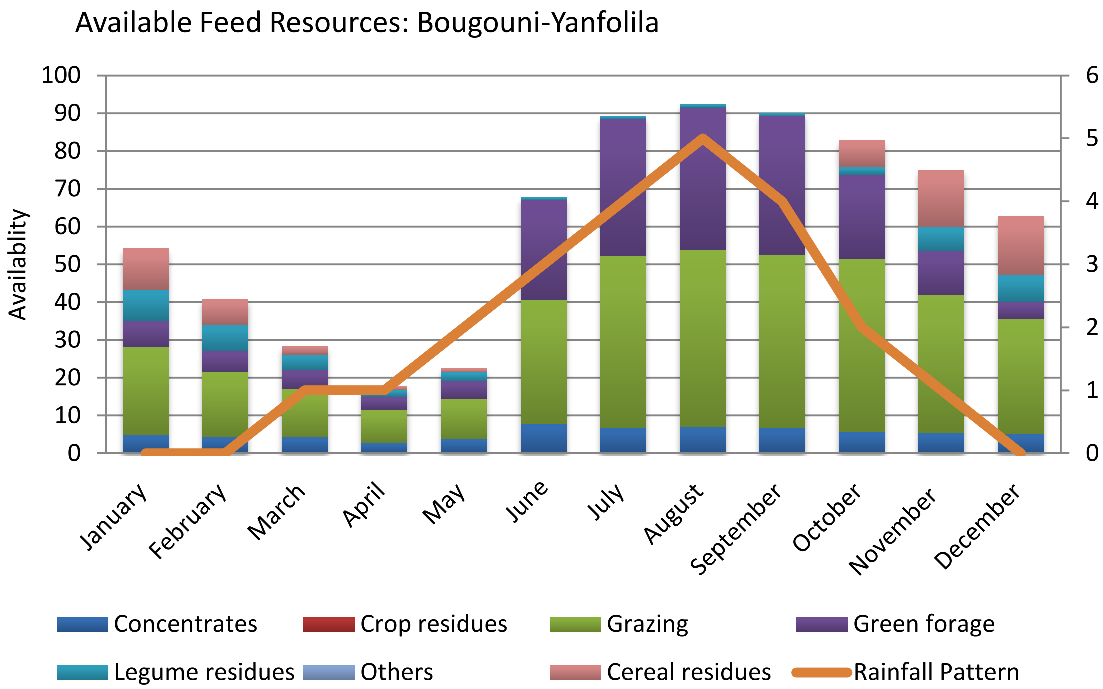


Figure 5. Sources of ruminant feed resources in intervention communities in the Upper East (a) and Northern (b) Regions of Ghana, 2013



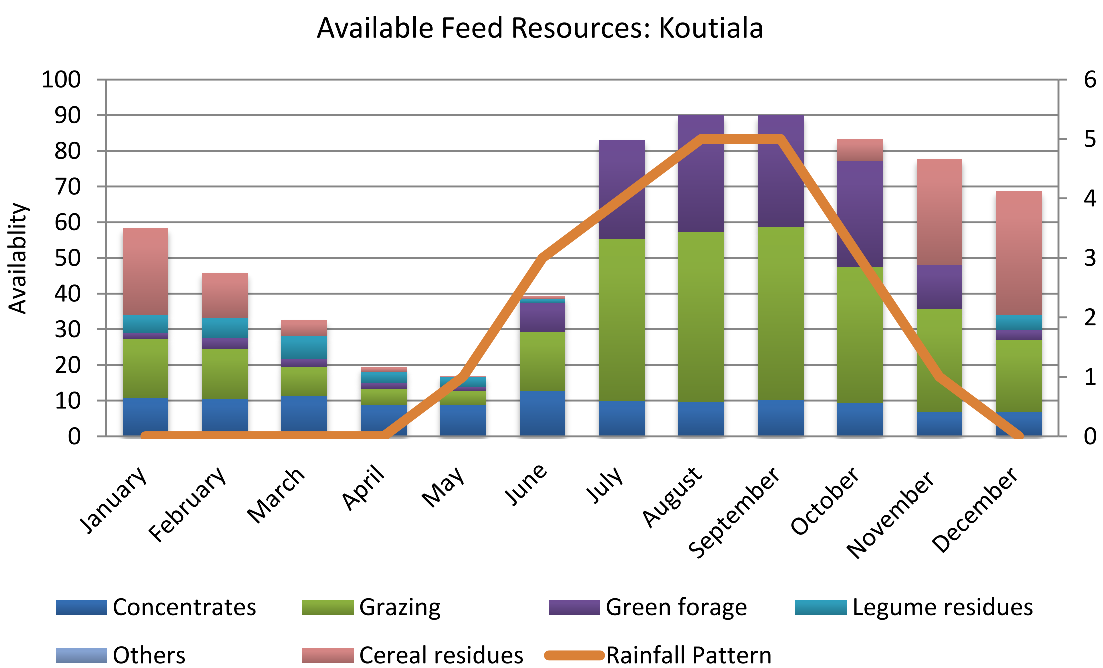


Figure 6. Feed resources availability in Bougouni-Yanfolila and Koutiala, Mali, 2013

2.1.3.4 Rural pig and poultry production
Two separate surveys were conducted by the University for Development Studies and the Kwame Nkrumah University of Science and Technology, respectively, to collect baseline information on the rural pig and poultry enterprise in selected Africa RISING intervention communities in Ghana. The objective was to determine major factors that affect production of rural pigs and poultry and find prospects for intensification and integration.

Table 8 presents a summary of the results from the pig survey involving 114 households. Farmers had their starter stock from their neighbors. The major source of finance for farmers was from the sale of pigs. Farmers largely described housing, health and inadequate feed as major challenges. Mainly mud houses roofed with thatch are provided for pigs. According to respondents, there was a ready market for pigs. They sold mostly bigger/older pigs as and when the need arose. Middlemen, *pito* (local beer) brewers and butchers were the main buyers.

Generally, respondents were not trained in pig production and records were not kept. There is need to develop affordable housing, formulate adequate but cheap diets, put in place good preventive health regimes and empower farmers with adequate knowledge and skills to facilitate integration of more intensive pig production with the other aspects of the farmers' agricultural enterprises.

The baseline survey of 180 households showed that domestic chickens and guinea fowl kept under semi-intensive management are the dominant species (Table 9). Most farmers provided mud-houses for their birds. Mating is uncontrolled, and brooding is mostly by the hens. Live birds are sold to generate cash for food, school fees or health bills. Key constraints to intensification of the poultry production system were: pests and diseases, high keet/chick mortality, predation, lack of technical know-how and feed shortages.


Ashanti Black Pig tethered. Photo: A. Larbi

2.1.3.5 Pearl millet cropping systems
As part of understanding the cereal-legume cropping systems at the Africa RISING intervention communities, focused group discussions were organized in five communities (Nyangua, Samboligo, Gia, Bonia and Tekuru) in the Upper East Region by ICRISAT and SARI research teams. A total of 85 respondents (26 women and 59 men) participated.

The discussions revealed various cereal-cereal and cereal-legume intercropping systems practiced by farmers in the Upper East Region (Table 10). The general practice is to interplant the component crops

on the same row. Millet (especially early millet) is often planted first with the early rains before the other crops are planted later in a relay cropping system. Very little is known about improved and quality seed as a factor for yield increases, meaning that there is need for more awareness promotion on the benefits of quality seed. Therefore, no conscious effort is made at acquiring and using them. Productivity of the cereal-cereal systems has not been documented, meaning that farming systems research is required to intensify the millet-sorghum-legume cropping systems.

Table 8. Characteristics of the rural pig farming in the Africa RISING intervention communities, Ghana, 2013

	Region (% of respondents)			
Breeds	Upper East	Upper West	Northern	Mean
Exotic	14.6	8.8	22.2	15
Local	78.2	82.5	77.8	80
Crosses	6.2	1.8	0	3
Production system				
Intensive	27.1	7	88.9	41
Semi-intensive	64.6	77.2	11.1	51
Extensive	8.3	8.8	0	6
Housing				
Enclosed structures	97.9	68.4	100	89
Confinement	22.9	5.3	100	43
Partial confinement	64.6	70.2	0	45
Feeding systems				
Complete feed only	23	24.6	100	49
Scavenging+Supplement	35.4	64.9	0	33
Scavenging only	8.3	1.8	0	3
Breeding system				
Uncontrolled mating	100	100	0	67
Controlled mating	0	0	100	33
Main health constraints				
Internal parasites	72.9	36.8	100	70
External parasites	2.1	1.8	0	1
African Swine Fever	2.1	5.3	11.1	6
Diarrhoea	2.1	0	0	1
Marketing				
Sale	66.5	70.1	88.9	75
No sale	33.5	29.9	11.1	25
Market channels				
Middlemen	47.9	35.1	77.8	54
Pito brewers	4.2	3.5	0	3
Butchers	35.6	35.2	66.7	46
Profitability				
Profitable	87.5	73.7	100	87
Not profitable	12.5	26.3	0	13

Table 9. Characteristics of the rural poultry farming in the Africa RISING intervention communities, Ghana, 2013

	Region (% of respondents)			
Item	UER	UWR	NR	Mean
Species				
Guinea fowl	100	76.3	64.3	80.2
Chickens	100	96.6	91.4	96.1
Turkeys	0	6.8	0	2.3
Ducks	19.6	15.3	4.3	13.1
Production system				
Semi-intensive	100	94.9	97.1	97.3
Free range	0	5.1	2.9	2.7
Housing				
Mud	78.4	96.6	87.2	87.4
Wooden	13.7	0	11.4	8.4
Others	7.8	0	1.4	3.1
Feeding systems				
Grains + scavenging	98	100	82.9	93.6
Feed + scavenging	0	0	14.3	4.8
Scavenging only	2	0	2.9	1.6
Breeding system				
Uncontrolled mating	100	100	100	100
Incub. & brood. by hen	100	100	100	100
Production constraint				
Pests and diseases	100	91.5	85.7	92.4
High keet mortality	78.4	69.5	68.6	72.2
Predation	82.4	69.5	61.4	71.1
Lack of knowledge	60.8	62.7	30	51.2
Feed shortage	56.9	62.7	25.7	48.4
Marketing				
Sale	94.1	89.8	97.1	93.7
No sale	5.9	10.2	2.9	6.3
Income source				
Income (birds)	96.1	84.7	50	76.9
Income (eggs)	3.9	5.1	44.3	17.8
Use of cash from sale				
Buying of food	86.3	79.7	78.6	81.5
Paying of schools fees	72.5	54.2	70	65.6
Health care	35.3	49.2	24.3	36.3

Table 10. Main cereal-legume and cereal-cereal cropping systems in the Upper East Region, Ghana, 2013

Community	First Crop	Second Crop
Nyangua	Maize	Sorghum
Nyangua	Millet	Cowpea
Gia	Sorghum	Maize
Gia	Early millet	Sorghum
Gia	Early millet	Late millet
Gia	Maize	Late millet
Gia	Groundnut	Sorghum
Tekuru	Groundnut	Late millet
Tekuru	Late millet	Cowpea
Tekuru	Maize	Late millet
Samboligo	Early millet	Sorghum (cowpea)
Samboligo	Early millet	Late millet/sorghum
Samboligo	Late millet	Groundnut
Bonia	Early millet	Late millet
Bonia	Maize	Late millet
Bonia	Maize	Groundnut
Bonia	Groundnut	Late millet (beans)

2.2 Integrated systems improvement (Research Output 2)

2.2.1 Livestock systems

2.2.2.1 Improved poultry housing

The University for Development Studies conducted a study in Bongo District of the Upper East Region of Ghana to assess effects of improved housing on performance of chickens. Ten farmers (7 men and 3 women) were purposively sampled for the study. Three hundred male chicks (non-commercial strain) at 4 weeks of age were randomly allotted into 20 groups of 15 birds per group and assigned to two treatments using a randomized complete block design, with a farmer serving as a block. Treatment 1 or control was the traditional housing (i.e. partial confinement) and birds managed under the free-range system. Treatment 2 was the improved housing (i.e. confinement) and birds managed under the intensive system. Growth and mortality data were collected.

The housed birds were 43.5% heavier than their free-range counterparts at 15 weeks of age (Table 11). This is because the housed birds had access to balanced diet ad libitum, unlike their free-range counterparts. The latter group had to scavenge for poor quality feed on the range with the occasional handful of grains supplied by the farmers. Mortality of housed birds was 19.5% lower than the control group. This could be due to better protection of the birds housed from adverse environmental conditions such as predation, accidents and contact with other diseased birds in the community. Economic evaluation showed that it was 46.2% more profitable to confine birds. Intensive rearing of poultry has been recognized as the surest way to improve productivity and profitability at the village level. However, this may require high initial capital outlay, which is often beyond the reach of most rural farmers. Thus any intervention in that respect must be combined with facilitation of access to financial support to farmers.

Table 11. Effect of housing on growth performance of male chickens (4-15 weeks of age), Ghana, 2013

Parameter	Housed birds Mean (±sd)	Free-range birds Mean (±sd)	P-value
Initial live weight (g/bird)	230 (0.0)	230(0.0)	-
Final live weight at 15 weeks of age (g/bird)	865 (124)	489 (96)	<0.001
Feed intake (kg/bird)	2.2	Not determined	-
Mortality (%)	6.6 (4.81)	8.2 (4.78)	0.465
Feed cost (GhS/bird)	1.80	Not determined	-

2.2.2 Ecological intensification of cereal legume systems

2.2.2.1 Maize: maturity type and nitrogen fertilizer rates

Responses of extra-early (80-85 days), early (85-100 days) and medium (100-110 days) maturing maize varieties to different nitrogen levels were evaluated in a multi-locational trial for the second year. The trials were established on station at Manga (UER), Wa and Tumu (UWR), and Damongo and Nyankpala (NR). For each maturity group, a split-plot design with four replications was used. Main plots were five maize varieties and sub-plots were five nitrogen fertilizer rates (0, 40, 80, 120 and 160kg/ha N). Each 6-row sub-plot measured 5.0m x 4.5m. Nitrogen was applied as urea in two equal doses. All plots received 60kg/ha P_2O_5 as Triple Super Phosphate (TSP) and 60kg/ha K_2O as Muriate of Potash (MOP) at planting. Days to tasseling, plant height and grain yield and 1000-grain weight were recorded.

In all locations, the maize variety by N rate interaction was not significant for all the parameters recorded for all the maturity types. Maize variety significantly influenced grain yield at Manga and Damongo, and nitrogen use efficiency (NUE) at Wa and Manga (Table 12). For each maturity group and at each location, maize had highest NUE at 40kg/ha N and the least at 160kg/ha N. Varietal differences in grain yield could be due partly to differences in days to anthesis and tasseling, plant height, 1000-grain weight and NUE.

Grain yield of the three maize maturity types generally increased non-linearly in response to increasing nitrogen rates in all the locations (Fig. 7). Reduction in nitrogen use efficiency with increasing N fertilizer rate may be partly responsible for the quadratic responses. Overall, increase in N rates beyond 80kg/ha did not result in significant increases in grain yield in most sites. Nitrogen fertilizer rates between 80 and 120kg/ha may therefore be ideal to optimize maize grain yields.

Table 12. Grain yield and nitrogen use efficiency of extra-early maturing maize varieties at Wa and Manga, Ghana, during the 2013 cropping season (values are means of 3 replications summed over 5 fertilizer rates)

Region	Site	Variety	Grain yield (kg/ha)	NUE (kg/kg N)
Upper West	Wa	99 TZEE Y STR	1147	8.4
		TZEE W POP STR QPM C0	1492	13.7
		2000 Syn EE W CO STR	1199	10.4
		2004 TZEE W POP STR C4	1045	9.8
		Abontem	1278	11.5
		LSD (0.05)	NS	NS
Upper East	Manga	99 TZEE Y STR	1180	11.9
		TZEE W POP STR QPM C0	1996	29.2
		2000 Syn EE W CO STR	1756	26.2
		2004 TZEE W POP STR C4	2349	33.9
		Abontem	2133	32.5
		LSD (0.05)	788	8.2
Northern	Damongo	99 TZEE Y STR	2629	na [1]
		TZEE W POP STR QPM	2304	na
		2000 Syn EE W C0 STR	3077	na
		TZEE W POP STR C4	2176	na
		Farmer's Variety	2388	na
		LSD (0.05)	592	na

[1]na=not afforded

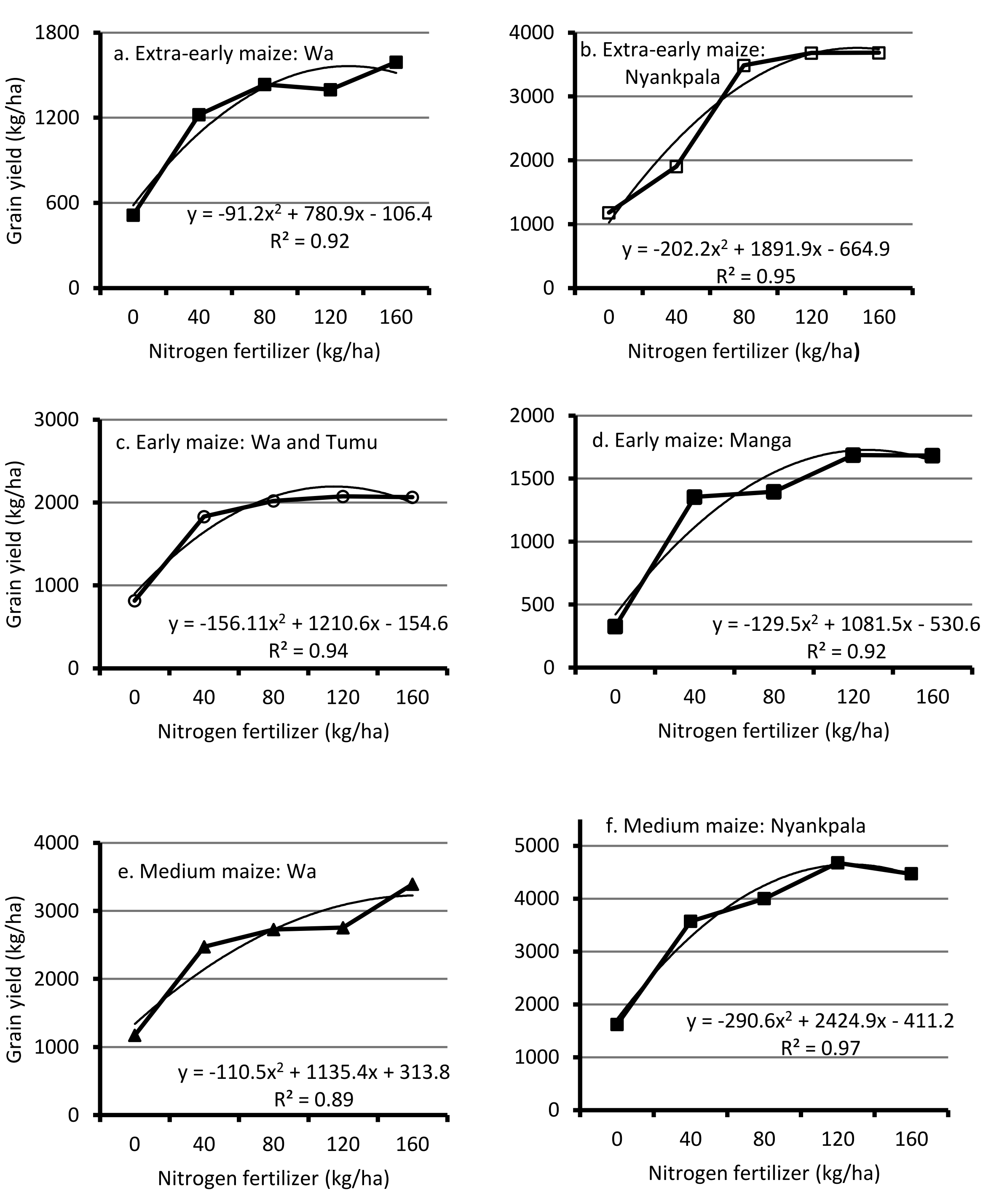


Figure 7. Responses of extra-early, early and medium-maturing maize varieties to nitrogen fertilizer rates, Ghana, 2013

2.2.2.2 Cowpea: variety and integrated soil fertility and pest management

Cowpea grain yield on farmers' fields is below 500kg/ha due to lack of seeds of improved cultivars at affordable prices, high incidence of diseases and pests, and inappropriate agronomic practices. Applying insecticides can control pests and increase grain and fodder yields. However, few farmers use

insecticides because they are costly and excessive use can harm the environment. Quantitative data on integrated soil fertility management effects on productivity of maize-cowpea rotations is limited.

Planting date, insecticide and cowpea variety effects on grain yield

Trial 1 evaluated the effects of planting date, insecticide application and cowpea variety on grain yield using a split-split plot design with three replicates. Main-plots were two insecticide treatments (Fig. 8a, b), sub-plots were four planting dates (see legend in Fig. 8), and sub-sub plots were six cowpea cultivars (Fig. 8). The sub-sub-plots consisted of four rows; 5m long spaced 0.60m between rows and 0.20m between plants in a row.

In Trial 2, the effects of four insecticide regimes on grain yield of six cowpea varieties were compared using a split-plot design with three replications. Main-plots were four insecticide spraying regimes listed in Table 13. Sub-plots were cowpea varieties used in Trial 1. The sub-plots consisted of 4 rows 5m long spaced 0.60m between rows and 0.20m between plants in a row.

In both trials, agronomic (days to 50% flowering and maturity, number of pods per plant, number of seeds per pod, haulm and seed yields) and insect population data were collected from the two middle rows in each plot. Populations of thrips and *Maruca vitrata* were estimated from flower bud formation to 50% podding by bringing 20 flowers in alcohol to the laboratory to count the insects. Populations of pod-sucking bugs were estimated by counting nymphs and adults. Pod damage by pod-sucking bugs and *Maruca* were estimated from a sub-sample of 100 pods after harvest.

Application of insecticide to control insect pests (Fig. 9b) resulted in significantly higher grain yields than no insecticide application (Fig. 9a). Grain yields were reduced significantly as planting was delayed from July to late August with the crop either sprayed or not sprayed. Spraying cowpea with insecticide once, twice or thrice during the growing season to control insect pests significantly increased grain yield in all cultivars (Fig. 9). It also reduced the population of insect pests and pod damage (Table 13).

The results suggest that cowpea farmers in the NR and UER should plant their crops between mid-July and early August for better grain yields. Judicious and timely application of insecticide at flowering and full podding can provide adequate control of key pests. Varieties IT99K-573-1-1 and IT99K-573-3-2-1 have high potential for grain production in northern Ghana due to their resistance to *Striga gesnerioides*.

Table 13. Spraying regime effects on insect population and pod damage in cowpea, Ghana

Insecticide spraying regime	[4]Pod sucking bugs	[4]Thrips	% pod damage
No spraying	12.3	22.2	70
[1]One spray	15.1	20.1	44
[2]Two sprays	4.6	12.5	43
[3]Three sprays	1.5	6.7	38
SED	1.93	3.92	6.9

[1]50% flowering (FPF)

[2]Flower bud initiation (FBI) and early podding (EP)

[3]FBI, FPF and FPF

[4]Population of pod-sucking insects and thrips on 20 flowers

SED: Standard error of difference

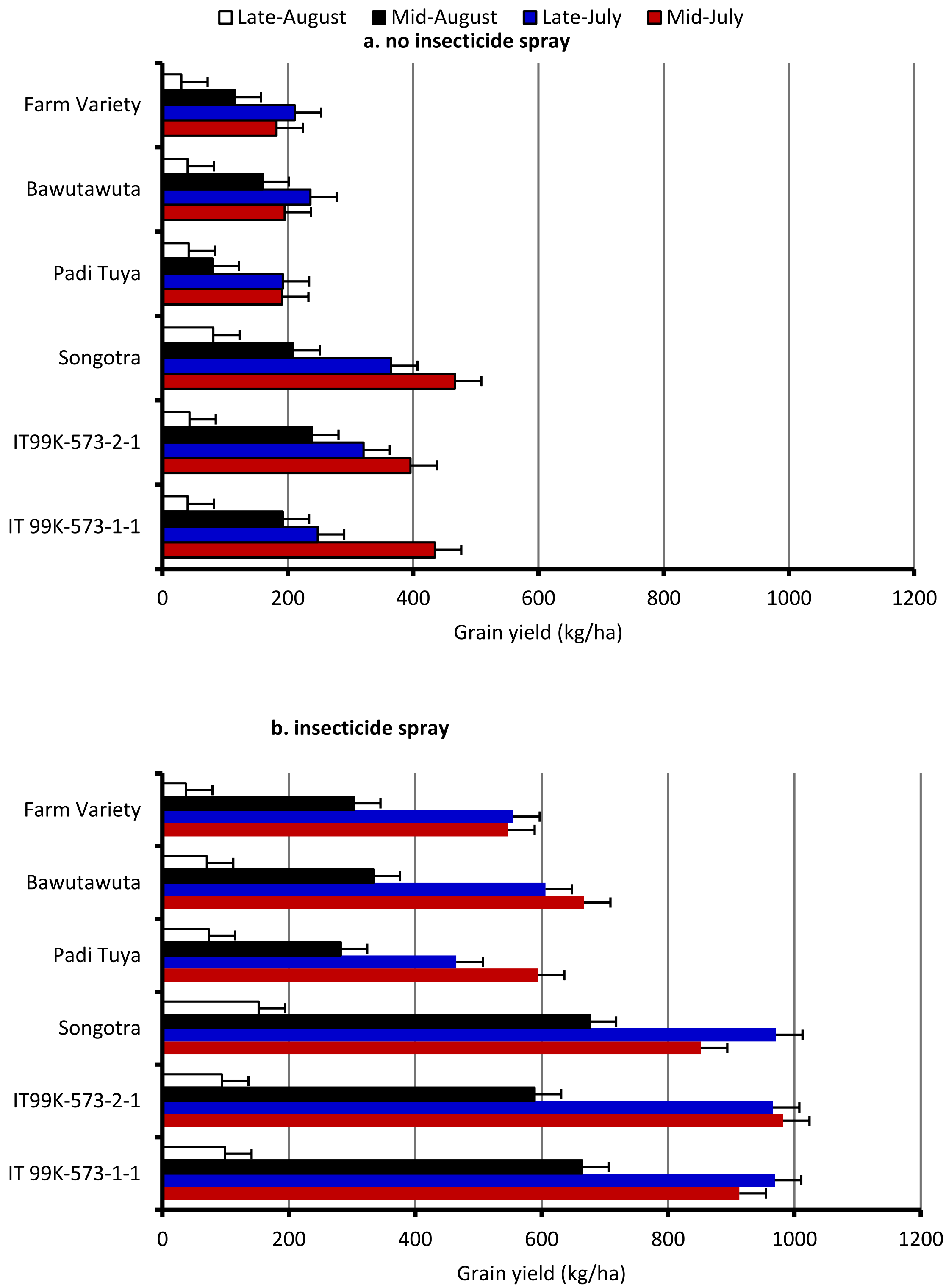


Figure 8. Grain yield of cowpea varieties as affected by planting date, and control of insect pest by spraying (b) or no spraying (a) of insecticides, Ghana, 2013

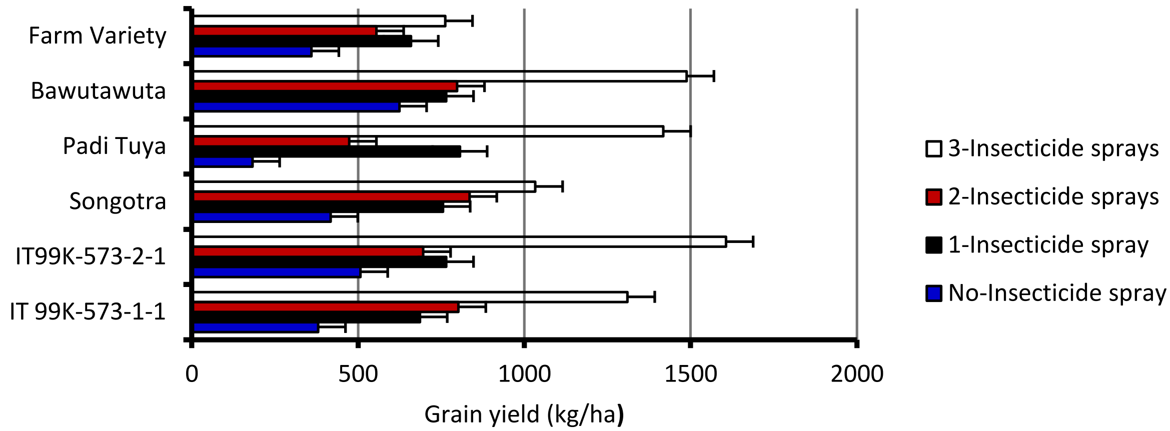


Figure 9. Insecticide spraying regime and variety effects on cowpea grain yield, Nyankpala, Ghana, 2013

Integrated soil fertility management effects on productivity of maize-cowpea rotations

An Integrated Soil Fertility Management (ISFM) study was initiated in 2013 to evaluate the response of a maize-cowpea cropping system to organic (fertisoil) and inorganic fertilizers and *Rhizobium* inoculants. The 2013 cropping season was the set-up year and therefore it was not possible to measure rotation effect of maize following soybean that received different fertilizer treatments.

The trials were conducted jointly conducted by SARI, IITA and KNUST researchers at Goriyiri (Nadowli district, UWR) and Bonia (Kassena-Nankan district, UER). The experimental design was a randomized complete block design with four replications and seven treatment combinations listed in Table 14. *Rhizobium* inoculants (5g/1kg of seed) and 1.5t/ha of fertisoil (organic fertilizer) were applied at planting. Recommended fertilizer rate was 25-60-30kg/ha as N, P_2O_5 and K_2O. The 60kg/ha P_2O_5 as Triple Super Phosphate (TSP) and 30kg/ha K_2O as Muriate of Potash (MOP) were applied at planting to plots that received P and K fertilizer. Plot size for each treatment was 4.5m x 5m. Plant height, days to 50% flowering, nodule number and weight, grain and stover yields, harvest index and 1000-grain weight was recorded. Farmers were actively involved in the planning, implementation, monitoring and evaluation processes.

Cowpea pod and nodule numbers and yields of grain and haulm were significantly affected by soil amendment treatment at Goriyiri (Table 14). Grain yield was highest for the treatment that received a combination of inoculants, PK and fertisoil, and lowest for the treatment with inoculants and fertisoil only. This result seems to suggest some synergy between *Rhizobium* inoculation and PK fertilization. Grain yield was positively correlated with nodule weight (r=0.66), nodule number (r=085), pod number (r=0.84) seed number (r=0.63) as well as biomass production (r=0.98).

Table 14. Soil amendment effects on agronomic traits of cowpea at Goriyiri, Upper West Region, Ghana, 2013 season

Soil amendment	Pod number	Nodule number	Grain yield (kg/ha)	Stover yield (kg/ha)
No soil amendment (control)	41	84	800	1134
Rhizobium inoculants only	33	90	800	1233
Inoculants + PK1	48	99	1067	2600
Inoculants + Fertisoil[2]	51	86	967	2066
Inoculants + PK + Fertisoil	58	86	1467	3300
[3]Recommended fertilizer rate	51	92	1000	2300
LSD (0.05)	11	11	239	1018

[1]P and K were applied at the rate of 60kg/ha P_2O_5 and 30kg/ha K_2O, respectively.
[2]Fertisoil was applied at the rate of 1.5t/ha.
[3]Recommended fertilizer rate was 25-60-30kg/ha as N, P_2O_5 and K_2O.

2.2.2.3 Soybean variety and integrated soil fertility management

A series of trials were conducted to evaluate options to intensify soybean production. Specific objectives were to demonstrate new soybean varieties to farmers; evaluate integrated soil fertility management effects on performance of soybean varieties in different environments; and determine farmer preferences for soybean varieties and ISFM technologies.

Soybean variety, inorganic fertilizer and Rhizobium inoculants effects on grain yield

Two trials were conducted using early-maturing (90-100 days) and late-maturing (100-115 days) soybean varieties. A split-plot design with four replications was used in both trials. Main plots were three early-maturing varieties listed in Table 15 in Trial 1, and five medium-maturing varieties listed in Table 15 in Trial 2. Sub-plots for both trials were five fertilizer treatments listed in Tables 14 and 15. The N, P and K rates were 25, 60 and 30kg/ha as N, P_2O_5 and K_2O, respectively. Nitrogen was applied as urea (46%N). Phosphorus was applied as Triple Super Phosphate (46%P_2O_5) and K as Muriate of Potash (60%K_2O). All fertilizers were applied in a subsurface band about 0.05m to the side of the soybean row. Plants were sown in July 2013. The early-maturing varieties were sown in six rows 5m in length and 0.6m apart, while the medium-maturing varieties were sown in six rows 5m in length and 0.75m apart. Distance between plants in a row was 5cm in all experiments with one seedling per stand. Weeds were controlled manually using a handheld hoe. Days to 50% flowering, plant height and grain yield were recorded. The two centre rows of each sub-plot were harvested at physiological maturity to determine grain and stover yields.

The soybean variety and fertilizer treatment interaction was not statistically significant for any traits measured or calculated at Wa. Variety significantly affected days to flowering and stover yield of the early-maturing soybean varieties at Wa (Table 15). Stover yield of Anidaso was significantly higher than of Suong-Pungu. *Rhizobium* inoculation and NPK application had no significant effect on any of the variables.

Anidaso had significantly more days to flowering, and higher grain and stover yields than Suong-Pungu at Bamahu (Table 16). Application of P and K fertilizer resulted in significantly higher stover yield compared to no fertilizer application. Suong-Pungu and TGX 1805-8F will be particularly useful in the drier areas in Upper East and Upper West Regions because they flower early. They could be used as a

relay crop to early millet in Upper East Region. This will enable farmers to benefit from both millet and soybean cultivation in one season, particularly in *Striga hermonthica*-endemic and drought-prone areas.

Results for the medium maturing soybean varieties are presented in Tables 17 and 18. At Wa, days to 50% flowering and grain yield varied significantly among the medium-maturing soybean varieties. Grain yield was highest for variety TGX 1834-5E or Afayak and lowest for variety TGX-1445-3E or Songda (Table 17), possibly due to the varietal differences in days to 50% flowering. Fertilizer and inoculation treatment significantly affected nodule weight and grain and stover yields. Grain and stover yields were highest with the combination of *Rhizobium* inoculation plus NPK fertilization and lowest when the seeds were neither inoculated nor fertilized. At Bamahu, variety had a significant effect on all the variables measured (Table 18). In contrast, *Rhizobium* inoculation and fertilizer application had no significant effect on any variable. Jenguma gave the highest grain and stover yields, while Songda gave the lowest.

In conclusion, soybean early-maturing genotypes TGX 1805-8F and Suong-Pungu were found to have potential for grain production in drier areas due to their early flowering nature. Medium-maturing genotypes with potential for higher grain production were TGX-1904-6F and Afayak. Inoculation of seeds with *Rhizobium* in combination with NPK fertilizer would increase grain yields.

Soybean grain yield responses to a combination of variety, organic and inorganic foliar fertilizers

In 2013, trials were carried out in 12 communities to evaluate a combination of variety and application of organic and inorganic fertilizers, including foliar fertilizers, in terms of soybean grain yield. The experimental design was a split-plot design arranged in randomized complete block with two improved varieties of soybean as the main plots and five integrated soil practices as sub-plots factor. Each community represented a replication. Each plot measured 5m x 4m with 2m alleys separating main plots and 1m alleys between sub-plots. Inoculated seeds of the two soybean varieties with *Rhizobium* at 5g of inoculants per 1kg seed were sown at 75cm by drilling except farmers' practice where no inoculation was done. Seedlings were later thinned to 5cm between plants in a row or 20 seedlings/m^2 with one plant per stand.

Table 15. Inorganic fertilizer and *Rhizobium* inoculation effects on performance of early-maturing soybean varieties at Wa, Upper West Region, Ghana, 2013

	Days to 50% flowering	Nodule weight[1] (g)	Nodule number[1]	Grain yield (kg/ha)	Stover yield (kg/ha)
Variety					
TGX 1799-8F (Suong-Pungu)	47	6.6	21	1911	1884
TGX 1805-8F	49	6.5	16	1902	2640
Anidaso	54	6.7	23	1956	2880
LSD (0.05)	2	NS	NS	NS	454
Fertilizer treatment					
No fertilizer	50	6.6	20	1926	2356
Rhizobium inoculation (R)	50	6.7	22	1867	2356
PK (60 kg P_2O_5+30 kg K_2O /ha)	50	6.6	16	1926	2474
NPK (2kg/ha N+60kg/ha P_2O_5+30kg/ha K_2O)	51	6.5	19	1970	2637
R +60kg/ha P_2O_5+30kg/ha K_2O	50	6.6	25	1926	2519
LSD (0.05)	NS	NS	NS	NS	NS

[1]Nodule number and nodule weight are for 10 plants/plot

The soybean variety by fertilizer treatment interaction had no significant effect on grain yield in all the regions. They main effect of variety was significant only in the Upper East where the genotype TGX-1904-6F produced more grain than the released variety Jenguma (Table 17). In general, grain yield tended to increase with a combination of TSP, fertisoil and the foliar fertilizer. Further studies are needed to confirm the results.

Table 16. Inorganic fertilizer and *Rhizobium* inoculation effects on performance of early-maturing soybean varieties at Bamahu, Upper West Region, Ghana, 2013

	Days to 50% flowering	Plant height (cm)	Grain yield (kg/ha)	Stover yield (kg/ha)
Variety				
TGX 1799-8F (Suong-Pungu)	44	49	996	693
TGX 1805-8F	44	59	1564	1493
Anidaso	49	57	1553	1493
LSD (0.05)	1	NS	379	339
Fertilizer treatment				
No fertilizer	44	56	1126	919
Rhizobium inoculation (R)	46	63	1284	1022
PK (60kg/ha P_2O_5+30kg/ha K_2O	46	65	1482	1422
NPK (25kg/ha N+60kg/ha P_2O_5+30kg K_2O)	45	71	1521	1393
R +60kg/ha P_2O_5+30kg/ha K_2O	46	78	1442	1378
LSD (0.05)	1	NS	NS	437

Table 17. Inorganic fertilizer and *Rhizobium* inoculation effects on performance of medium-maturing soybean varieties at Wa, Upper West Region, Ghana, 2013

	Days to 50% flowering	Nodule[1] weight (g)	Nodule[1] number	Grain yield (kg/ha)	Stover yield (kg/ha)
Variety					
TGX 1834-5E (Afayak)	51	9.1	68	2465	2744
TGX 1445-3E (Songda)	56	8.6	27	1849	2676
TGX 1448-2E	49	8.7	45	2276	253
TGX 1904-6F	48	8.4	31	2406	2782
Jenguma	52	8.1	23	2145	2764
LSD (0.05) ‡	1	NS	NS	316	NS
Fertilizer treatment					
No fertilizer	51	8.7	29	1898	1864
Rhizobium inoculation (R)	52	9.0	55	2169	2444
PK (60kg/ha P_2O_5+30kg/ha K_2O)	51	8.6	46	2382	2862
NPK (25kg/ha N+60kg/ha P_2O_5+30kg/ha K_2O)	51	8.6	41	2394	2960
R+60kg/ha P_2O_5+30kg/ha K_2O	51	8.8	43	2381	2880
LSD (0.05)	NS	0.21	NS	316	383

[1]Nodule number and nodule weight are for 10 plants/plot

Table 18. Inorganic fertilizer and *Rhizobium* inoculation effects on performance of medium-maturing soybean varieties at Bamahu, Upper West Region, Ghana, 2013

	Days to flowering	Plant height (cm)	Pods per plant	Grain yield (kg/ha)	Stover yield (kg/ha)
Variety					
TGX 1834-5E (Afayak)	48	60	63	1520	1716
TGX 1445-3E (Songda)	53	47	71	871	1005
TGX 1448-2E	47	58	49	1244	1778
TGX 1904-6F	46	59	49	1316	1662
Jenguma	47	60	41	1511	2143
LSD (0.05)	1	5	12	308	354
Fertilizer treatment					
No fertilizer	48	57	49	1164	1591
Rhizobium inoculation (R)	48	55	49	1244	1564
PK(60kg/ha P_2O_5+30kg/ha K_2O)	48	57	58	1431	1511
NPK (25kg/ha N+60kg/ha K_2O_5+30kg/ha K_2O)	47	58	56	1449	1849
R+ PK (60kg/ha P_2O_5+30kg/ha K_2O)	48	56	60	1173	1787
LSD (0.05)	NS	NS	NS	NS	NS

Table 19. Soybean grain yield (kg) as influenced by inorganic and organic fertilizer and liquid foliar fertilizer in Ghana

Treatment	Northern Region			Upper East			Upper West		
	Jenguma	TGX-1904-6F	Mean	Jenguma	TGX-1904-6F	Mean	Jenguma	TGX-1904-6F	Mean
Farmer practice[1]	2000	1333	1667	444	667	556	800	844	822
TSP[2]	1778	1333	1556	533	756	645	711	578	645
Fertisol (F)[3]	1778	1778	1778	622	844	733	667	489	578
TSP+F	2000	2000	2000	533	931	732	978	533	756
TSP+F+BoostXtra[4]	2222	2000	2111	400	978	689	489	844	667
Mean	1689	1689	1689	507	835	671	729	658	694
S.E	241.4			163.9			176.2		
Probability of F-value									
Treatment(T)	0.3441			0.9667			0.8474		
Variety(V)	0.3908			0.0099			0.5375		
TxV	0.1561			0.7566			0.2993		

[1]Farmer practice = no *Rhizobium* inoculation, TSP, F and BoosXtra

[2]TSP = Triple Super Phosphate at 60kg/ha P_2O_5

[3]Fertisoil = organic fertilizer applied at 4t/ha

[4]BoostXtra = liquid foliar fertilizer applied 4l/ha

Integrated soil fertility management effects on productivity of maize-soybean rotations

An ISFM study was initiated in 2013 to evaluate the response of maize-soybean rotations to organic (fertisoil) and inorganic fertilizers and *Rhizobium* inoculants. The 2013 cropping season was the set-up year and therefore it was not possible to measure rotation effect of maize following soybean that received different fertilizer treatments.

The trial was conducted at Goriyiri (Nadowli district, UWR) and Bonia (Kassena-Nankan district, UER) using the same procedure outlined in section 2.3.2. The experimental design was randomized complete block design with four replications and seven treatment combinations listed in Table 17. *Rhizobium* inoculants (5g/1kg of seed) and 1.5t/ha of fertisoil (organic fertilizer) were applied at planting. Recommended fertilizer rate was 25-60-30kg/ha as N, P_2O_5 and K_2O. The 60kg/ha P_2O_5 as Triple Super Phosphate (TSP) and 30kg/ha K_2O as Muriate of Potash (MOP) were applied at planting to plots that received P and K fertilizer. Plot size for each treatment was 4.5m x 5m. Plant height, days to 50% flowering, nodule number and weight, grain and stover yields, harvest index and 1000-grain weight were recorded. Farmers were actively involved in the planning, implementation, monitoring and evaluation processes.

Soybean plant height, nodule numbers and yields of grain and stover were significantly affected by soil amendment treatment in Goriyiri (Table 20). Grain and stover yields were highest when inoculants, PK and fertisoil were applied and lowest when no soil amendment was applied. At Bonia, the soil amendments had similar significant effect on the agronomic traits of soybean. Grain yield was highest with inoculation plus PK suggesting some synergy between *Rhizobium* inoculation and PK fertilization, and lowest when only *Rhizobium* inoculation was applied (Table 20). Soybean grain yield was positively correlated with plant height (r=0.60) and biomass production (r=0.82).

Table 20. Soil amendment effects on agronomic traits of soybean at two location in northern Ghana, 2013 season

Intervention community	Soil amendment	Plant height (cm)	Nodule number	Grain yield (kg/ha)	Stover yield (kg/ha)
Goriyiri (Upper West)	No soil amendment (control)	41	84	800	1134
	Rhizobium inoculants only	33	90	800	1233
	Inoculants + PK[1]	48	99	1067	2600
	Inoculants + Fertisoil[2]	51	86	967	2066
	Inoculants + PK + Fertisoil	58	86	1467	3300
	[3]Recommended fertilizer rate	51	92	1000	2300
	$LSD_{(0.05)}$	11	11	239	1018
Bonia (Upper East)	No soil amendment (control)	32	-	901	1900
	Rhizobium inoculants only	37	-	880	1917
	Inoculants + PK	41	-	1361	2167
	Inoculants + Fertisoil	41	-	1758	3217
	Inoculants + PK + Fertisoil	40	-	1582	2867
	Recommended fertilizer rate	39	-	1304	2217
	LSD (0.05)	9.8	-	254	932

[1]P and K were applied at the rate of 60kg/ha P_2O_5 and 30kg/ha K_2O, respectively
[2]Fertisoil was applied at the rate of 1.5t/ha
[3]Recommended fertilizer rate was 25-60-30 kg/ha as N, P_2O_5 and K_2O

2.2.3 Genetic intensification of cereal-legume-vegetable systems

2.2.3.1 Medium-maturing and dual-purpose cowpea

Twelve lines of each of the medium-maturing and dual-purpose cowpea types were evaluated in separate trials using a randomized complete block design with three replications. Each plot measured 4m x 4m with 1m alleys between plots and 2m alleys between replicates. Seeds were sown at 75cm x 20cm apart and within rows respectively. Two seeds were sown per stand.

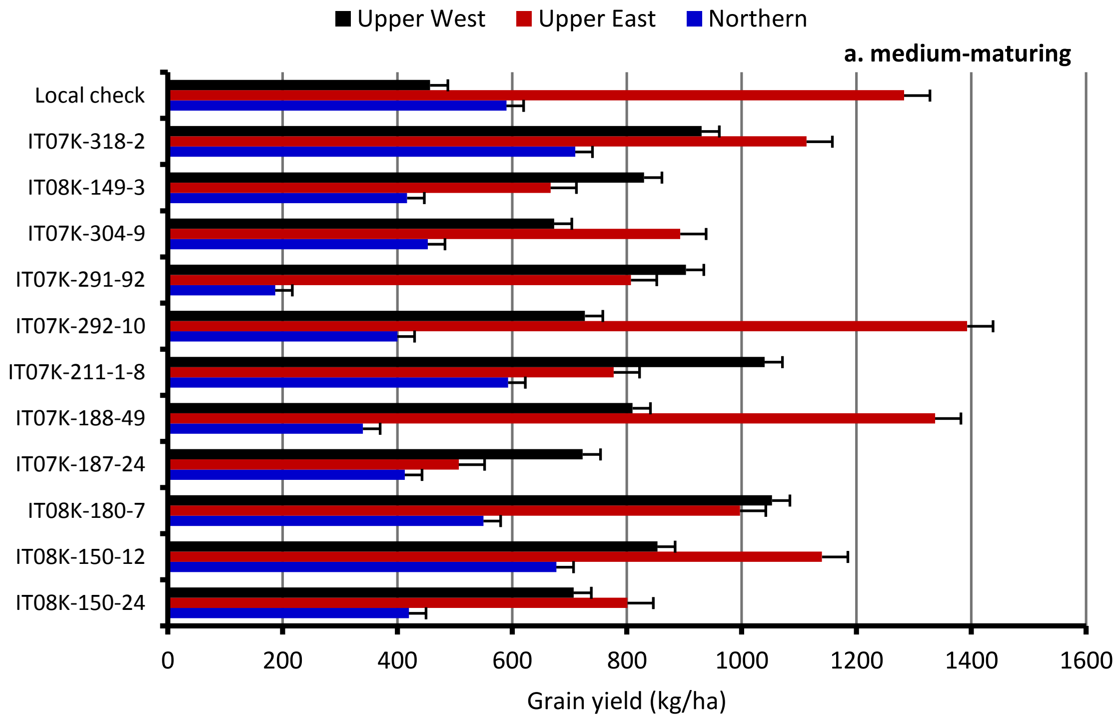
Pre-emergence herbicide was applied immediately after sowing to control weeds. Weeding was done at 4 and 7 WAP. Cymetox Super (30g of Cypermethrin and 250g of Dimethoate of active ingredient per liter), a systemic and contact insecticide for the control of insect pest on a range of field crops and vegetables, was applied at the rate of 1.5l/ha for insect pest control. Cymetox Super was replaced with Lambda Super 2.5E.C (25g of Lambda-Cyhalothrin) in the three spraying regime during the third spray to prevent insects developing immunity to the first chemical.

Grain yield of the medium-maturing (Fig. 10a) and dual-purpose (Fig. 10b) cowpea types varied significantly among the genotypes in all regions. Yields in the drier Upper East region were generally higher than the Northern and Upper West regions, possibly due to lower insect pest damage. Averaged across regions, medium-maturing genotypes IT07K-318-2, IT08K-150-2 and IT08K-180-7; and dual-purpose genotypes IT09K-321-21, IT09K-456 and IT08K-126-19 were identified to have potential for grain production in northern Ghana.

2.2.3.2 Early- and late-maturing soybean

Sixteen early-maturing soybean genotypes were evaluated at Botingli, Siriyiri and Samboligo in the NR, UWR and UER, respectively. The same number of medium-maturing genotypes was established in separate trials at Duko, Passe and Bonia in the NR, UWR and UER, respectively. In both trials, a randomized complete block design with three replications was used. Each plot measured 4m x 4m with 1m alleys between plots and 2m alleys between replicates. Seeds were drilled at 75cm apart and were later thinned to 20 seedlings per meter. Pre-emergence herbicide (Lumax 537.5 SE) was used at 4l/ha to control weeds whiles hand weeding was done 5-6 weeks after sowing. Days to 50% flowering, nodulation, pest and diseases, plant height at harvest, days to maturity, dry pod weight and grain yield were recorded.

Grain yield varied significantly among the early-maturing (Fig. 11a) and medium-maturing (Fig. 11b) soybean genotypes in all the regions. Grain yield of the early-maturing genotypes was higher than the late-maturing in all regions, possibly because the rains started late and planting was delayed. Grain yield in the Upper East Region was generally lower than in the other regions probably due to the differences in the length of the growing season. Averaged across regions, soybean genotypes with potential for grain production were the early-maturing genotypes TGX-1990-55F, TGX-1990-57F and TGX-1990-37F; and the late-maturing genotypes TGX-1990-80F, TGX-1990-47F and TGX-1989-42.



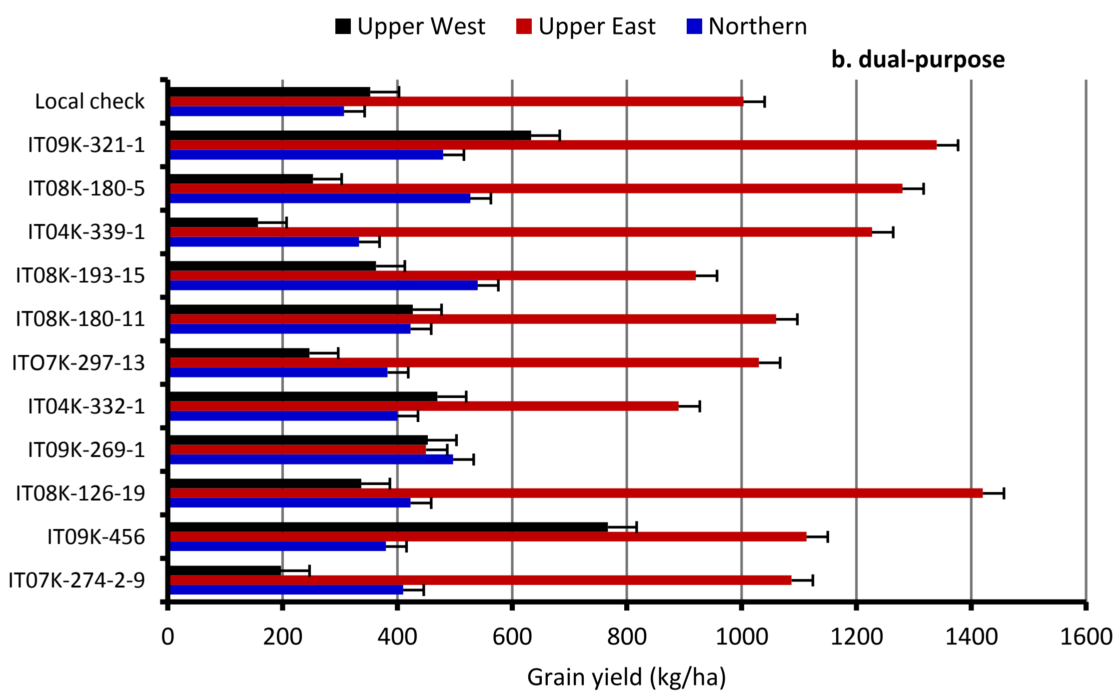


Figure 10. Grain yield of medium-maturing and dual-purpose cowpea varieties in intervention communities in the Northern, Upper West and Upper East Regions, Ghana, 2013

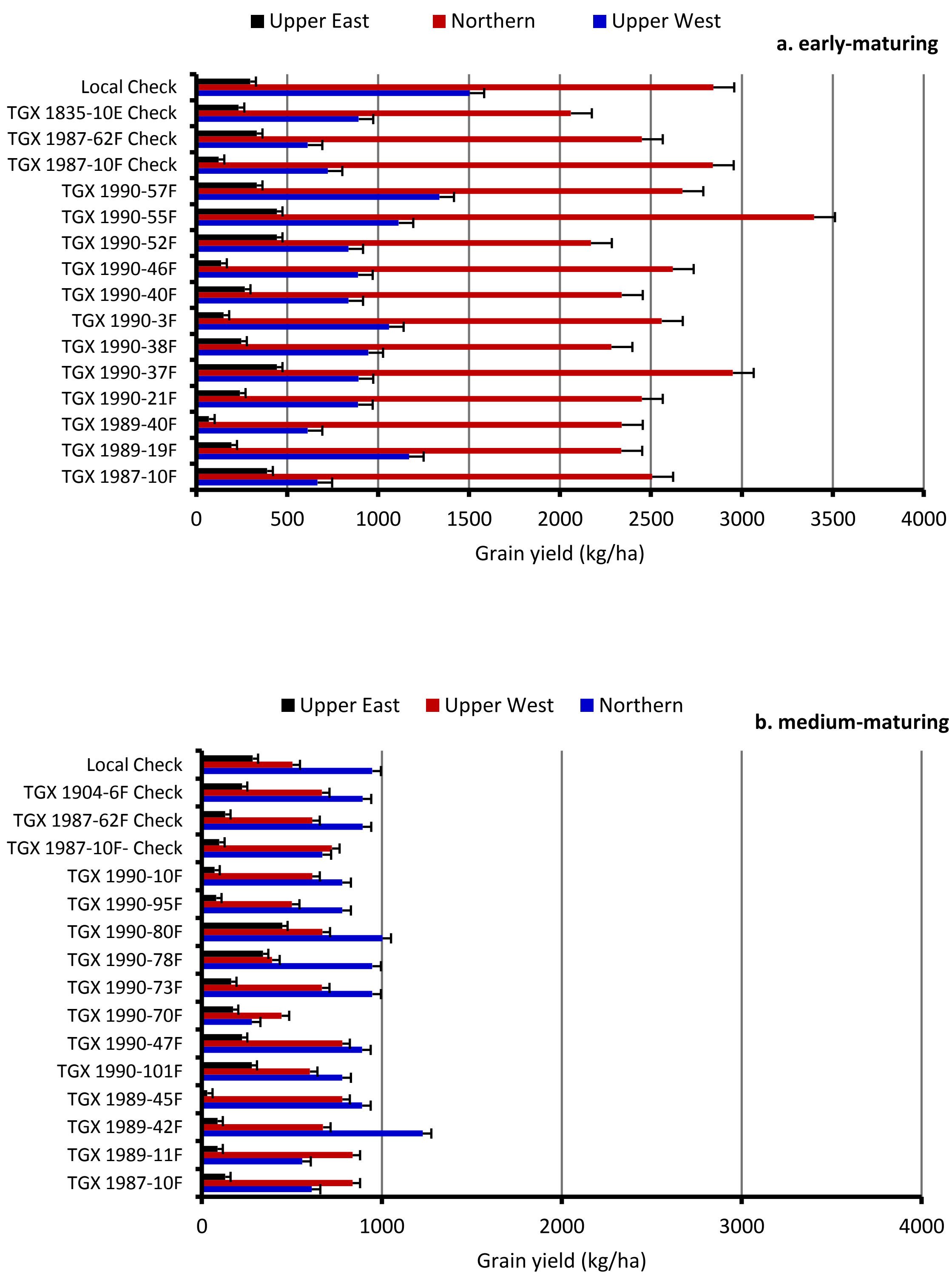


Figure 11. Grain yield of early- and medium-maturing soybean varieties in intervention communities in the Northern, Upper West and Upper East Regions, Ghana, 2013

2.2.3.4 Aflatoxin resistant groundnuts

A team from ICRISAT and SARI established field trials at Tingoli, Sabulungo and Nyagli in the NR, UER and UWR respectively to evaluate the performance of 10 groundnut genotypes consisting of eight aflatoxin resistant lines from ICRISAT-Mali, one improved variety (Nkate-SARI) and a popular local variety (Chinese). Grain and haulm yields varied significantly among the groundnut genotypes (Fig. 12). The preliminary results showed that the farmer variety and the aflatoxin resistant genotypes ICGV-94379 and ICGV-91317 have potential for grain and fodder production, whilst the aflatoxin resistant genotype ICVG-91315 and the released variety NKATESARI have potential for fodder production.

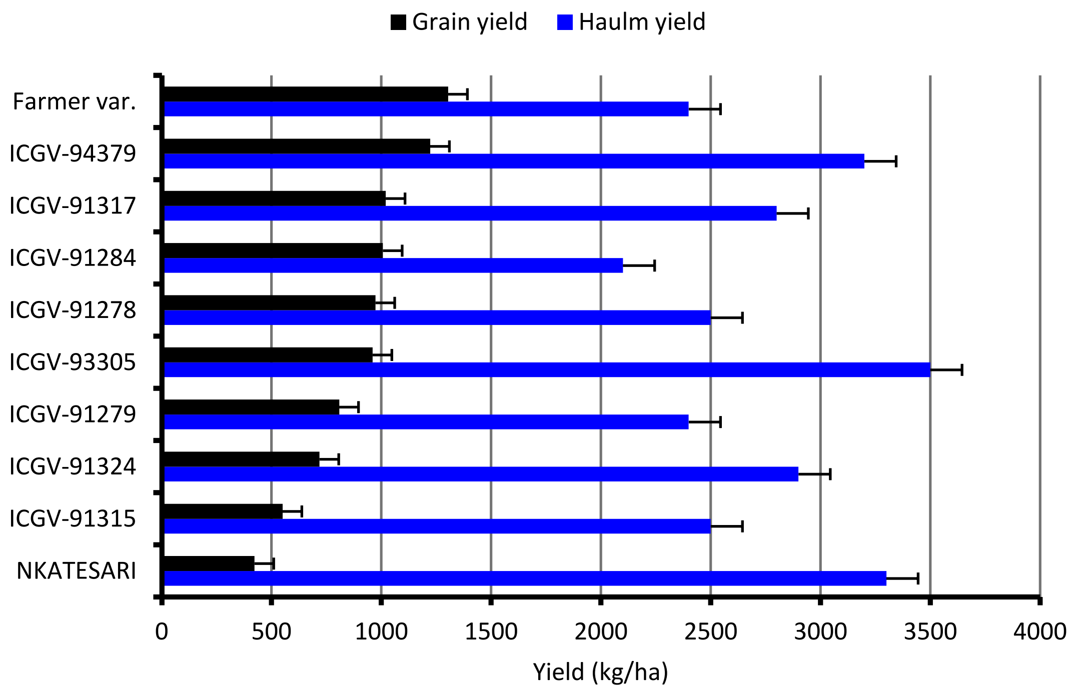


Figure 12. Grain and haulm yield of aflatoxin resistant groundnut genotypes at Sabulungo, Upper East Region, Ghana, 2013

2.2.3.5 Sorghum hybrids

Eleven hybrids were compared with the commonly cultivated local sorghum in the area using an Alpha design at Manga in the UER. The hybrids were sown on ridges in six rows of 5m in length and 0.75m apart. Three seeds per hill were planted at 0.30m apart and later thinned to two plants per hill. Basal fertilizer (15:15:15) was applied at the rate of 38-38-38kg/ha as N, P_20_5 and K_2O. Top-dressing was done 4 weeks after planting at the rate of 26kg/ha N using sulphate of ammonia. Data were collected from the two centre rows.

Genotypic differences were detected for plant height, grain yield, and harvest index (Table 21). The shortest hybrid was IPSA1527530 while the tallest was Sewa. Mean grain yield was lowest for Soumalemba and highest for IPSA Golofing. Mean grain yields of Fadda, Yamassa and IPSA Golofing were 37-57% higher than the local variety Kadaga. Grain yield was positively correlated (r=0.94) with the harvest index (grain yield*100/total biomass). Grinkan Yerewolo and the local variety were the most preferred by farmers whilst IPSA156731 was the least preferred. Kadaga was preferred for its brown grain that is ideal for brewing *Pito*.

Table 21. Performance of sorghum hybrids at Wa, Upper West Region, Ghana, 2013

Genotype	Plant height (cm)	Grain yield (kg/ha)	Harvest index (%)
Caufa	283	2233	41
Fadda	313	2567	43
Grinkan Yerewolo	346	2133	40
IPSA156731	325	2200	40
IPSAGolofing	255	2900	46
IPSA1527530	166	1933	36
Kadaga (local variety)	310	1867	37
Mona	297	2233	42
Pablo	306	2567	44
Sewa	382	1767	35
Soumalemba	277	1633	34
Yamassa	218	2800	45
LSD (0.05)	96	764	7

2.2.3.6 Vegetables

SARI and AVRDC scientists evaluated okra, roselle and tomato genotypes on-farm (Sabulungo, Tekuru and Bonia) and on-station (Manga) in the UER. Farmer Field Schools and Participatory Variety Selection were conducted for both male and female farmers from nine communities.

The okra genotypes were planted at a spacing of 30cm between plants in rows 75cm apart, replicated two times with a plot size of 4m x 8m. Plant counts at two weeks after planting and at harvesting; plant height; days to 50% flowering and 50% fruiting; and number and weight of fruits were recorded.

Fruit yield varied significantly among the okra genotypes (Fig. 13). Genotypes NOKH 1002, NB-55-Srivan, NOKH 1003, NOKH 1004, AAK, EX-makutopora and FV-Unn-manna were found to be early-maturing (50% flowering 40-50 days after planting); Sasilon, ML-OK-16, ML-OK-37, TZ-SMN-86, Kpora-napon and Kpora-nasong were of the medium-maturity type (attained 50% flowering after 50 days of planting); while genotypes ML-OK-16, ML-OK-10, P1496946, FV-Unn and FV-Kpazeya were late-maturing, i.e., attained 50% flowering after 60 days of planting.

High yield, early maturity, multiple harvest frequency and drying quality were identified by farmers as the most important selection criteria, especially under irrigated dry season production. Other criteria included prolonged tenderness, fruit size, price, taste, fruit texture and tolerance to field stress. Based on farmer preference and performance, genotypes NOKH 1004, NB-55-SRIVAN, Sasilon and NOKH 1002 were selected for further evaluation on farmers' fields.

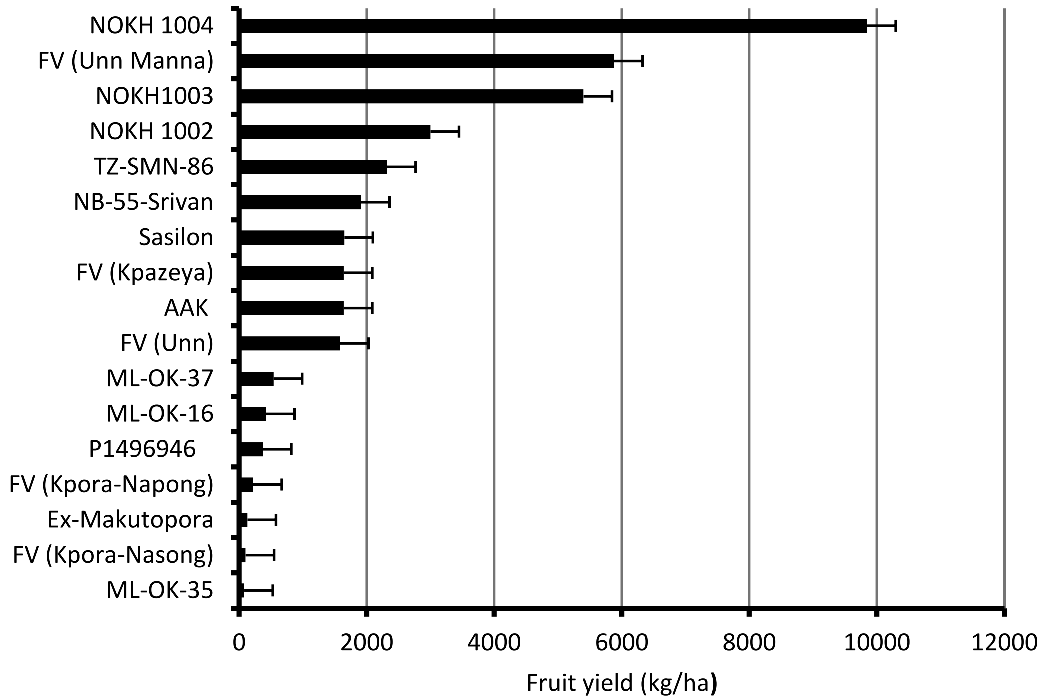


Figure 13. Fruit yield of okra genotypes at Manga, Upper East Region, Ghana, 2013 season

Six tomato genotypes *(Duluti, LBR7, LBR 16, LBR17, Tengeru 97 and Keneya)* were evaluated on-station at Manga in the Upper East Region under rainfed condition using a randomized complete block design with three replications. Seeds were planted in June 2013 in rows 0.75m apart and 0.30m between plants within a row. Plant counts 2 weeks after planting and at harvesting; plant height at 4, 8 and 12 weeks; days to flower initiation; days to 50% flowering and 50% fruiting; number of fruits at 70, 80, 90 and 100 days after planting; and fruit size were recorded.

Fruit yield varied significantly among genotypes (Fig. 14). Genotypes LBR 17, LBR 7, LBR 16 and Keneya were found to have potential for production under rain-fed conditions.

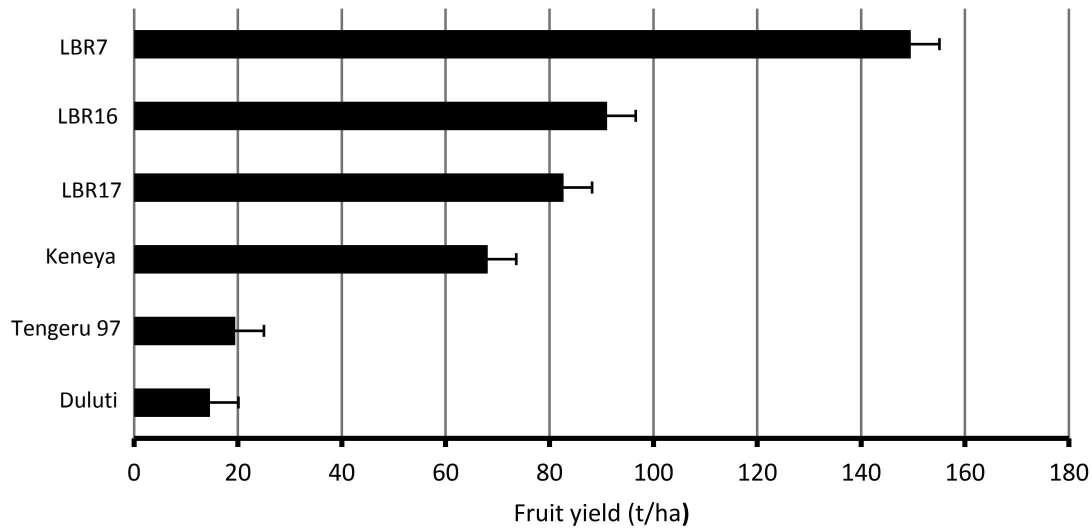


Figure 14. Fruit yield of tomato genotypes at Manga, Upper East Region, Ghana, 2013 season

2.2.4 Seed production

Limited access to quality seed of improved varieties, partly due to non-availability of seeds at affordable prices, was listed by farmers as a major constraint to crop production during the community analysis in Ghana and Mali. Therefore, linkages were established with public and private sector partners to produce and/or multiply seeds – breeder, foundation and certified seeds. The objective was to increase the accessibility of farmers to quality seeds of improved varieties. The seed multiplication plots were also used to demonstrate new crop varieties and to train farmers on good practices for vegetable production.

In Ghana, IITA scientists partnered with CRI to produce breeders' seeds; with GLDB to produce foundation seeds; and with the Seed Producers Association of Ghana, SARI and community-based seed producers to produce certified seeds of cereals and legumes (Appendix 1). In Mali, a team consisting of AVRDC and AMEDD staff produced seeds of three vegetable species (Appendix 2). The breeder seeds will be used for production of foundation seeds, whilst the certified seeds will be used for participatory research with farmers in the intervention communities.

2.3 Scaling-up and delivery (Research Output 3)

As stated in Section 1.3, participatory approaches are used to implement the project activities, disseminate new technologies and promote knowledge exchange. For example, the "mother and baby" approach was used to disseminate several technologies and combinations of technologies in Ghana and Mali. In Ghana, for example, the following combinations of technologies were demonstrated to more than 700 farmers: (i) maize varieties and fertilizer application; (ii) soybean varieties and integrated soil fertility management; and (iii) cowpea varieties and insecticide spraying regimes. Similarly, in Mali the approach was used to reach out to more than 500 farmers.

Farmers Field Days and Farmers Field Schools were jointly organized by SARI and AVRDC on vegetable production for farmers from Azum-sapielga, Badu, Boku, Tekuru, Bonia, Tampezua, Mognori, Nyorigu, Manga and Nayorko communities in the UER in Ghana. More than 250 farmers participated (Table 22). The Ministry of Food and Agriculture organized six field days for over 1000 farmers to demonstrate several technologies in mother trials in NR, UER and UWR of Ghana.

Farmers field day in UWR, Ghana, and *Striga* infested sorghum crop in UER, Ghana. Photos: A. Larbi

In Mali, ICRISAT in partnership with AMEDD and Access Agriculture, an international NGO, distributed "Fighting *Striga"* DVDs to Africa RISING action villages. They studied the early impacts of the distribution and use of the DVDs and videos on partner dynamics, farmer knowledge and experimentation in Mali, including in several Africa RISING villages. A contract was signed with the Cinema Ambulante Numerique for the evening large-screen viewing of five "Fighting *Striga"* videos in all Africa RISING villages.

In Ghana, ICRISAT partnered with MoFA and Access Agriculture to produce 5,000 DVDs on "Fighting *Striga"* in the Kusaal, Frafra, Dagbaari and English languages. The video was launched in Tamale on 17 July. Three videos – "*Striga* biology", "Grow row by row", and "Let's talk money" – were shown in five Africa RISING intervention communities (Nyangua, Bonia, Tekuru, Samboligo and Gia) in UWR.

Table 22. Number of farmers attending the Farmer Field Schools and Participatory Variety Selection, Ghana

		Attendance		
Districts	Communities	Male	Female	Total
Binduri	Nayorko	5	20	25
Binduri	Boku	5	20	25
Binduri	Azum-Sapielga	5	20	25
Bawku-East	Nyorigu	5	20	25
Bawku-East	Mognori	10	20	30
Bawku-East	Tampizua	10	20	30
Bawku-East	Bado	6	10	16
Kassina-East	Tekuru	15	30	45
Massena-East	Bonia	10	25	35
Total	9	71	185	256

2.4 Capacity building and knowledge exchange

Individual and group trainings were an integral part of the project activities during the reporting period. Thirteen graduate students jointly supervised by staff of Africa RISING and national universities were attached to the project for their dissertation research (Table 23). Group training in the form of short-term courses, hands-on training and exchange visits were also organized. A team of scientists working on the project in Ghana visited Mali in October 2013 to learn and exchange knowledge.

Table 23. Graduate students attached to Africa RISING West Africa

Student	Sex	Country	University	Degree
Mary Awuni	Female	Ghana	University for Development Studies	MSc
Richard Amponsah	Male	Ghana	Kwame Nkrumah University of Science and Technology	MSc
Raphael Azayiga	Male	Ghana	Kwame Nkrumah University of Science and Technology	PhD
Abdul R Nurudeen	Male	Ghana	Kwame Nkrumah University of Science and Technology	PhD
Sarfo K Goodman	Male	Ghana	Kwame Nkrumah University of Science and Technology	PhD
Fatouma Traore	Female	Mali	University of Ghana	MSc
Martha Agyri	Female	Ghana	Kwame Nkrumah University of Science and Technology	MSc
Solomon Konlan	Male	Ghana	University for Development Studies	PhD
Clarisse Umutoni	Female	Mali	Cheik Anta Diop University, Dakar, Senegal	PhD
Peter Agbetiameh	Male	Ghana	Kwame Nkrumah University of Science and Technology	PhD
Joseph Clottey	Male	Ghana	University of Ghana	MSc
Emmanuel Gyakah	Male	Ghana	University of Ghana	MSc
Mohammed Shaibu	Male	Ghana	University of Ghana	MSc

Fruit tree establishing plot set up by ICRAF and visited during researchers exchange visit to Mali in October 2013.
Photo: I. Hoeschle-Zeledon

3 Project implementation issues

A review and planning meeting was held in Tamale, Ghana, on 11 December 2013. From 3-5 February 2014, the annual review and planning meeting for Ghana and Mali was held in Bamako, Mali. Monthly partner meetings in the three regions of Ghana have been initiated to better coordinate and oversee the activities.

An agricultural economist for the two IITA-led regional Africa RISING projects has been recruited as international staff and will start work out of the Tamale, Ghana office in April 2014. The Project Administrator resigned in November 2013. This position was merged with the Project Accountants' position. The communications specialist hired in November 2013 for the two regional projects resigned and will leave in April 2014. The position will be upgraded to allow recruitment of a highly qualified international staff member able to address the growing communication needs.

A Memorandum of Understanding was signed with Heifer International, an NGO dealing with livestock related issues, in November 2013. The MoU with ACDI-VOCA expired in December 2013 due to the ending of the ADVANCE project. There is interest by both parties to renew the MoU should the project be extended for another phase.

The Africa RISING West Africa project is co-located with the country office of the N2Africa and SARD-SC projects at the IITA premises in Tamale.

The activity coordinator in Mali resigned from the partner institution, ICRISAT, early 2014. He has been replaced by a new staff member. This has been the second change in leadership of the Mali activities within 14 months, with associated implications for institutional knowledge and continuity of activities and relationships.

The USAID ban on supporting government institutions in Mali has been lifted in October 2013. Therefore, the project can partner again with IER, a key national research partner.

In the absence of data from the baseline surveys to be carried out by IFPRI, the different teams had to carry out a number of smaller surveys to inform their research activities. IFPRI has now made preparations to carry out the baseline surveys in April/May 2014 in both countries.

The regional M&E officer, a consultant hired by IFPRI, resigned in January 2014 leaving the position again vacant and disrupting the collaboration with Africa RISING implementation partners in both countries.

The USAID Mali Mission is investing approximately US$9,000,000 in large-scale technology dissemination to boost the sorghum and millet value chains in Sikasso and Mopti Regions of Mali. The Mission has asked ICRISAT to prepare a proposal for 36 months. Though funds will be channeled directly to ICRISAT, this project will become a component of Africa RISING with reporting to USAID through the Africa RISING Coordinator for West Africa. The Africa RISING regional management will be represented on the Management Committee of this new component. Start of activities is expected immediately.

4 Presentations and publications

Buah, SS., Larbi, A., Hoeschle-Zeledon, I. (2013). Grain yield responses of maize to nitrogen fertilizer in the West Africa Guinea savannah. *6th International Nitrogen Conference, Kampala, Uganda, 18-22 November 2013*.

Denwa, N., Buah, SS., Larbi, A., Hoeschle-Zeledon, I. (2013). Soybean grain yield responses to NPK fertilizer and *rhizobium* inoculation. *6th International Nitrogen Conference, Kampala, Uganda, 18-22 November 2013*.

Kanton, RAL., Larbi, A., Buah, SS., Kombiok, JM., Ansoba, E., Aungre, PA., Lamin, S., Prasad, PV. (2013). Effect of nitrogen fertilizer on growth and yield of maize varieties with different maturities in a dry agro-ecology of northern Ghana. *Annual General Meeting of the Crop Science Society of America (CSSA)/ Soil Science Society of America (SSSA) and the American Society of Agronomy (ASA), Tampa, Florida, 3-7 November 2013*.

Hoeschle-Zeledon I. and Larbi A., 2014. Sustainable Intensification of Crop–Livestock Farming Systems in the Guinea and Sudan Savanna Zones of West Africa. Africa RISING Brochure. IITA, Ibadan, Nigeria.

in preparation:

Katja Kuivanen, Mirja Michalscheck, Sahib u Mellon, Samuel Adjei-Nsiah, Stephanie Alvarez, Asamoah Larbi, Ken Giller, Katrien Descheemaeker, Jeroen Groot. Exploration of farm type specific options for sustainable intensification of smallholder farming systems in the West-African Savannah zone: Whole farm model application in northern Ghana. *Agricultural Systems.*

5 Success story

Turning over a new leaf: Amaranth in Africa

Mrs. Ephraim Lukumay, a farmer in Bermi village, Dareda ward, Babati District of Tanzania, didn't think too highly of amaranth a few years ago. "We did not know the nutritive importance of this vegetable," she said.

Proud Mrs. Lukumay in her amaranth field.
Photo: Inviolate Mosha, AVRDC

Today she grows amaranth to consume at home and to sell to neighbors and at markets. She is a participant in the Africa RISING East and Southern Africa Project, an initiative to improve agricultural production knowledge and access to modern technologies, such as high performing vegetable varieties in the sub-region. As part of the project, Mrs. Lukumay and 70 other farmers learned good production and post-harvest practices and farm record-keeping skills during training sessions hosted by AVRDC – The World Vegetable Center's Eastern and Southern Africa office in September 2013. To get them off to a good start, participants

also received seed of improved tomato, amaranth, African eggplant and sweet pepper.

Now about 85% of the trained farmers are growing amaranth as well as other crops. “Before we did not have good quality seeds, such as what we have now in our fields,” said Mrs. Lukumay. “We are not using any pesticide; the crop is fast-growing and very palatable. I grow amaranth in my home garden, and I am confident that I can now contribute some money to solve some family problems and not only depend on my husband to provide us with everything."

‘Madira 1’, the amaranth variety distributed by AVRDC, grows well in the local environment. “We can harvest for a long time by cutting the leaves—for about six months if we manage it right,” said Mrs. Lukumay. She described her production method: “I harvested amaranth from my plot of 3 by 15 meters for over 10 weeks since the first week of October 2013. The first harvest was by thinning; then I left the other plants in a spacing of about 20 by 30 centimeters and then continued to cut the leaves after every vegetative growth.”

Mrs. Lukumay with her daughter explaining how they dry amaranth seeds for sowing in the coming season using a direct solar dryer.
Photo: Inviolate Mosha, AVRDC

Her family of five consumes about 0.5kg of amaranth every day, and she sells more than 10kg every week. “Many people like the amaranth variety we grow from AVRDC seed,” she said. “It tastes good and it is very nutritious. Most of my customers are pregnant mothers and families with children under five. When they visit pre-natal clinics, the nurses tell them to eat more amaranth!”

Mrs. Lukumay handing over to daughter Nembris the income of the day’s sales of amaranth.
Photo: Inviolate Mosha, AVRDC

Mrs. Lukumay’s 13-year-old daughter, Nembris, is the family cashier. Nembris attends Dareda Secondary School in Babati from Monday through Friday from 7.00am to 4.30pm, then assists her mother in the vegetable garden for one hour after school and almost 2 hours on Saturdays. “We have TZS 20,000 cash in hand as at now,” Nembris said. “When we began selling amaranth I didn’t keep record but now I do, and we made TZS 50,000 during the last two and a half months.” Nembris has advised her school mates to grow amaranth to improve the nutrition of their family and to make money to be able to cover some of their needs in school.

Mrs. Lukumay said she appreciated the opportunity to enhance her vegetable production skills through the AVRDC training course. “This training made us aware of the benefits of amaranth,” she said. “This crop is now very attractive to us as farmers, because of the income it can bring, and the nutrition it provides.”

Nembris keeping record of income from amaranth sales.
Photo: Inviolate Mosha, AVRDC

Appendix 1

Breeder, foundation and certified seed produced in Ghana, 2013

Type	Crop	Variety	Seed produced (kg)
Breeder seed	Maize	Obatanpa	750
		Nangbaar	200
		Total	*950*
	Soybean	Anidaso	300
		Asomdwee	250
		Total	*550*
	Cowpea	Videza	250
		Oboshie	350
		Hewale	250
		Total	*850*
	Groundnut	Obolo	350
Foundation seed	Maize	Omankwa	1000
		Abontem	300
		Obatanpa	50
		Sub-total	*1,350*
	Cowpea	Asontem	300
Certified seed	Maize	Abontem	2745
		Abrohemaa	1215
		Omankwa	630
		DTXR-WCoF$_2$	675
		Sub-total	*5,265*
	Rice	Gbewaa rice	16, 465
	Soybean	Jenguma	2565
		TGX-1940-6F	450
		Sub-total	*3,015*
	Cowpea	Songotra	1530
		Padi-Tuya	180
		Apagbuala	270
		Zaayura	585
		Sub-total	*2,565*

Appendix 2

Vegetable seed produced in 2013

Species	Country	Varieties	Seed produced (kg)
Jute Mallow	Ghana	6	2.2
Amaranthus	Ghana	7	4.2
Pumpkin	Ghana	10	8.2
African Nightshade	Ghana	9	7.7
Roselle	Ghana	9	13.8
Okra	Ghana	15	17.5
Sub-total			53.6
Tomato (ICRIXINA)	Mali	1	4.2
Okra	Mali	2	78
Roselle (Koor)	Mali	1	10.3
Hot pepper (Natama)	Mali	1	0.9
Sub-total			93.4
Grand-total			147